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Wastewater Facilities and the Clean Water Plan

Environmental Protection Agency, Denver, Colo Region VIII

Jun 77

PB 272 864

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DENVER REGIONAL ENVIRONMENTAL IMPACT STATEMENT FOR WASTEWATER FACILITIES AND THE CLEAN WATER PROGRAM

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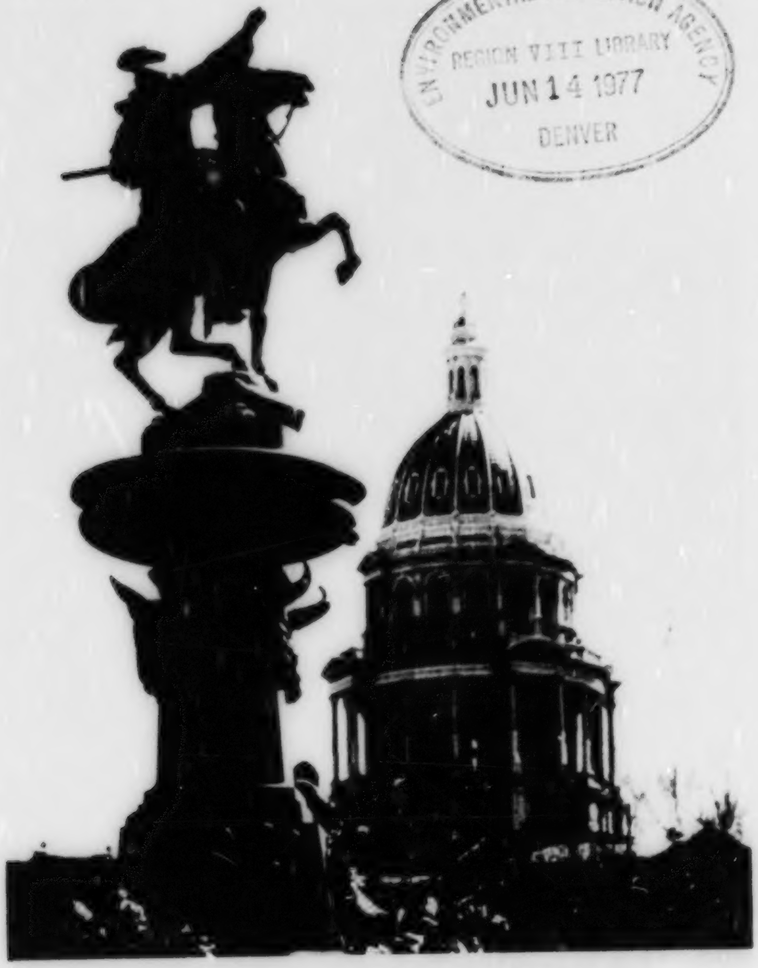

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Hydrology,
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Recreation,
Abatement,
Energy,
Substitutes,
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DENVER REGIONAL

ENVIRONMENTAL IMPACT STATEMENT

for

WASTEWATER FACILITIES
and the
CLEAN WATER PLAN

Prepared by

U.S. ENVIRONMENTAL PROTECTION AGENCY

REGION VIII, DENVER

June 1977

Approved By:
John A. Green
Regional Administrator

Denver Region
Section 201 Facility Plans
Section 208 Area Management Plan

(X) Draft ( ) Final Environmental Statement

1. Name of Action: (X) Administrative ( ) Legislative

2. Description of Action: Various local agencies have proposed or are developing proposals to construct, improve and/or expand municipal wastewater collection and treatment systems for the following eight planning areas:

1. South Adams County
2. Englewood and Littleton
3. South Lakewood
4. Cherry Creek and Goldsmith Gulch
5. Lower South Platte
6. Clear Creek and Sand Creek
7. Westminster and Broomfield
8. Metropolitan Denver Sewage Disposal District No. 1

Planning for these municipal wastewater collection and treatment system modifications has or will be carried out with local agency and EPA funds under Section 201 of Public Law 92-500. These planning efforts examine a number of alternative means of achieving effluent standards derived from water quality goals. The Denver Regional Council of Governments (DRCOG), the designated 208 planning agency, has released the draft Clean Water Plan (208 plan), for public review. As the draft Clean Water Plan addresses the same water quality issues, and must be also approved by EPA, this action is included with the actions required for the eight facility (201) plans.

The Environmental Protection Agency has received or is anticipating requests to fund 75 percent of the construction costs for wastewater collection and treatment facilities for eight service areas in the Denver Region and to approve the Clean Water Plan. Each of these funding requests for proposed projects and the approval of the Clean

Water Plan represents a proposed major federal action by EPA which may have a significant effect on the quality of the human environment. Under the provisions of the National Environmental Policy Act (NEPA), EPA must prepare an Environmental Impact Statement, and consider the environmental consequences thus disclosed before making a decision as to whether to provide the requested funds and approvals.

The purpose of preparing one EIS for eight project proposals and the Clean Water Plan, instead of a separate EIS for each project proposal, is to provide a framework for examining cumulative regionwide effects. Experience has shown that regionwide environmental effects of wastewater collection and treatment facilities for urban areas are linked to the future growth those facilities are designed to serve. The EPA is concerned that actions it may take to improve regional water quality goals may jeopardize the attainment of other environmental goals.

3. Environmental Impacts:

(1) The region will continue to grow in both population and urbanized areas at the expense of existing and potential agricultural areas. The existing, complex framework of government agencies will hinder the solutions of region-wide problems.

(2) Urban sprawl is expected to continue with the migration of the affluent and advantaged to the suburbs. Out-migrants from the urban core will be replaced in large measure by the poor, the old, minorities and the disadvantaged. Economic growth in the suburbs will be more rapid than in the urban core. Physical and economic decay of the urban core is expected.

(3) Damage to park and recreational facilities resulting from overuse or vandalism will continue and intensify as park acreage per capita ratio decrease.

(4) Public health and soil damage impacts will occur as a consequence of agricultural irrigation with wastewater treatment plant effluent unless State of Colorado and local public health and agricultural officials establish effective effluent quality standards.

(5) Particulate air pollution concentrations can be expected to increase in future years resulting in continued violation of the National Ambient Air Quality Standards. The major sources for particulates will continue to be related to construction activities, and materials on streets thrown up by vehicular traffic.

(6) With the implementation of a vehicle emission inspection and maintenance program, carbon monoxide concentrations on a regional scale will be near to but still exceed standards in 1985. Peak ozone concentrations will continue to violate standards for the same year. By the year 2000, carbon monoxide on an average regional basis will meet

standards, but high volume traffic corridors and intersections will continue to have "hot spot" carbon monoxide violations. Peak ozone concentrations will be near, but still occasionally exceed standards. The high per capita usage of the automobile by residents of the Denver region will continue to be the major source of carbon monoxide, ozone and particulates pollution.

(7) The implementation of any of the three major alternatives or the recommendations of the Clean Water Plan will likely result in an improvement in existing stream quality, but not in a degree sufficient to meet 1983 goals.

(8) The region will experience natural gas supply shortfalls by 1978-1979.

(9) Increased dependence on coal for electrical power generation will create new water allocation and quality problems.

(10) Energy is not likely to be conserved to the degree necessary to avoid natural gas supply shortfalls or to reduce the region's future dependence on coal-generated electricity.

(11) Construction site erosion and runoff will continue to be an important short-term impact on water quality throughout the region.

(12) Stream channelization and related activities such as diversions and culverting in newly developing areas will adversely affect the aquatic environment at points throughout the region, particularly in upstream locations.

(13) Industrial and mining activities along the region's streams will continue to adversely affect riparian and aquatic habitats.

(14) Continuing development of all types will disrupt riparian corridors.

(15) Future development in foothill and upland areas will disturb the habitats and ranges described in Section IV.

(16) A number of unique habitat areas will be disturbed by future development, overuse of sites, trespassing and vandalism.

(17) The Regional Transportation District will continue having difficulties competing with the automobile and achieving the utilization of its bus fleet until such time the automobile becomes an economically undesirable means of transportation.

(18) Susceptibility to losses to topsoil and economic losses in agricultural sector under drought conditions is likely to increase.

(19) Continued development in wind corridors will increase the potential for Chinook-related damages to some degree.

(20) Increased traffic volumes on stream valley thoroughfares will increase the occurence and severity of fog-related traffic problems.

(21) Aesthetically unattractive and potentially hazardous hillside development is likely to occur in some jurisdictions.

(22) Some significant and unique geologic structures and formations in the region are likely to be damaged or defaced by overuse and vandalism.

(23) Some mining-related hazards will threaten the safety and wellbeing of local residents in some jurisdictions.

(24) Aerosols and local fogs will be produced at the facilities.

(25) Erosion and run-off impacts would likely be unavoidable if the wastewater treatment plant construction-related mitigation measures recommended in Section V, Mitigation Measures for Direct Impacts, are not carried out.

(26) Construction will eliminate human-sensitive wildlife species from the project sites.

(27) Treatment plant odors should be considered an unavoidable impact because of the unexpected nature of the climate and operations upset conditions resulting in their production.

4. Alternatives:

Three strategies for wastewater treatment facilities, and the Clean Water Plan recommendations were evaluated. The three strategies are termed Local, Regional, and No-action. The Local alternative strategies essentially embodies the recommended alternative of each individual Facility Plan completed or in preparation. This alternative is very similar to the Clean Water Plan recommendations for wastewater treatment facilities, which essentially call for the upgrading or construction of local and satellite wastewater treatment plants. The Regional alternative calls for the transport of areawide wastes to a central regional plant for treatment. The No-action alternative is the likely result of no EPA grant funding for design and construction of wastewater treatment facilities. The No-action alternative basically involves delays in the construction of facilities.

5. Distribution:

The list printed at the end of this EIS shows the agencies, groups, and individuals requested to comment on the draft statement.

6. Draft Statement Sent to Council on Environmental Quality: May 27, 1977.

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I. Introduction

SECTION I

INTRODUCTION

The Denver metropolitan area includes nearly 60 percent of the population of the State of Colorado. It is located geographically near the middle of the state where the eastern plains of Colorado meet the Rocky Mountain foothills (see Figure I-A and Map A).

BACKGROUND

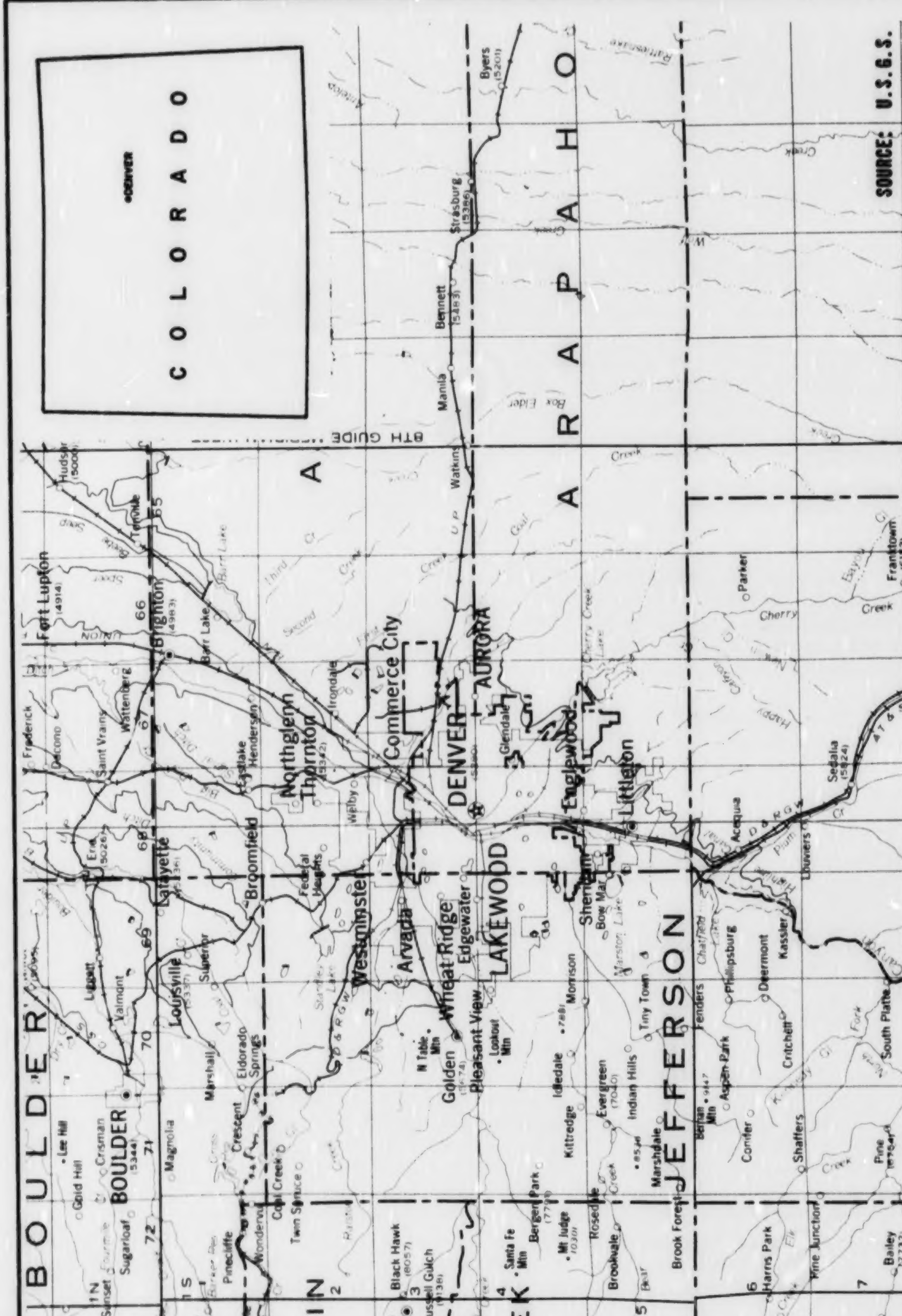
In 1969 a law of far-reaching significance for Federal agencies was passed by Congress. This law, called the National Environmental Policy Act (and referred to as NEPA), requires a Federal agency to take account of and make known the environmental impacts of any major action it is about to undertake. The agency must decide whether a given action is a major one that will have a significant effect on the environment. The document that a Federal agency must prepare on such a major action is called an environmental impact statement (EIS).

The Environmental Protection Agency (EPA) is responsible for seeing to it that many of the environmental laws passed by Congress are put into effect; however, it is also one among many Federal agencies which must also comply with NEPA in its own actions.

In 1972, EPA became responsible for implementing the Water Pollution Control Act Amendments (P.L. 92-500). This law among other things established water quality goals for U.S. Waters:

> 1. "...wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983," and
>
> 2. "...that the discharge of pollutants into navigable waters be eliminated by 1985."

The law set up a comprehensive planning process involving EPA and the State to define the necessary stream water quality standards and treatment levels to achieve these goals, and how they would be attained. The law created the National Pollutant Discharge Elimination System (NPDES) of permits to regulate and control discharges to the Nation's streams. Congress also set aside $18 billion in grant funds to pay 75% of the eligible costs of publicy owned waste treatment works to assist municipalities in achieving the necessary plant


COLORADO
DENVER
BOULDER
ADAMS
ARAPAHOE
JEFFERSON
GILPIN
CLEAR CREEK
DENVER
AURORA
LAKEWOOD
Commerce City
Northglenn
Thornton
Westminster
Arvada
Wheat Ridge
Edgewater
Englewood
Littleton
Sheridan
Glendale
Golden
Broomfield
Lafayette
Louisville
Brighton
Fort Lupton
Boulder
Castle Rock
Parker
Strasburg
Bennett
Byers
Watkins
8TH GUIDE MERIDIAN
Scale 1:500,000
10 Miles
10 Kilometers

SOURCE: U.S.G.S.

RELATION OF DENVER REGION TO THE STATE OF COLORADO effluent quality to meet the water quality goals.

The Environmental Protection Agency is charged with overseeing most of these and other provisions of the Act. Two areas of EPA responsibility under the Act are brought together in this EIS effort.

Section 201 of the Act provides for a three-step facilities planning, design, and construction approach to secure Federal funds for municipal wastewater treatment works. Step I involves the development of a "facilities plan" that evaluates treatment needs, systems capacities, alternatives, and develop a preliminary design for the project. EPA is charged with review and approval of such Step I plans before design (Step II) and construction (Step III) funds can be obtained. An integral part of the EPA's review involves an assessment of environmental impact that the facility plan defines.

Section 208 of the Act is also administered by EPA. This is a special planning function that analyzes complicated water pollution problems on a regional or Statewide scale. Where the Governor of a State identifies a major water pollution problem, a 208 agency is designated to develop this comprehensive planning approach to the problem. 208 planning involves defining point and non-point sources wasteload projections, treatment needs and priorities, a closer evaluation of stream classification, the necessary controls and the type of mangement to achieve the goals of the Act. Such a plan in effect will set many of the criteria to be developed in individual 201 facilities plan for the study area.

ACTIONS UNDER CONSIDERATION IN THIS EIS

The 201 Facility Plans

Various local agencies have prepared or are developing facility plans to construct, improve and/or expand municipal wastewater collection and treatment systems for the following planning areas (see Map J):

1. South Adams County
2. Englewood and Littleton
3. South Lakewood
4. Cherry Creek and Goldsmith Gulch
5. Lower South Platte
6. Clear Creek and Sand Creek
7. Westminster and Broomfield
8. Metropolitan Denver Sewage Disposal District No. 1

Each of these wastewater treatment facility plans must identify the most cost-effective and environmentally sound alternative after considering the local and regional implications of the project. Considered together, these projects raise significant regional issues which must be addressed, such as population levels and distribution, air quality, conversion of agricultural land, protection of environmentally sensitive areas, point and non-point pollution control, etc. There has been a great deal of discussion lately between citizen groups and various levels of government concerning the best way to address these regional issues. A regional environmental study has been developed as one possible way to evaluate these issues. EPA's policy in the past has been to evaluate wastewater treatment facility plans in the Denver metropolitan area on a project-by-project basis and to prepare the individual project environmental impact statements, if necessary. The analysis of regional issues and secondary impact questions has been difficult using a project-by-project approach. EPA acknowledges this difficulty in the final EIS for the present plant expansion by the Metropolitan Denver Sewage Disposal District No. 1 (February, 1974), in the final EIS for the Englewood-Littleton sewage treatment plant (August, 1974) and in the negative declaration for the South Platte II interceptor sewer (September, 1975), where EPA indicated the intention to prepare a regional environmental impact statement addressing these broader issues.

As indicated above, there are other wastewater treatment projects that are in various stages of construction, some of which have been the subjects of individual EIS's. Although not directly affected by the EIS effort, it is EPA's intention to apply any reasonable mitigating measures to any of those projects beginning or still under construction. The on-going Denver area projects not directly covered in this EIS are as follows:

1. City of Boulder's wastewater treatment plant improvement program with EIS now in preparation;
2. City and County of Denver's interceptors in the Harvard/Jewell area, which are now under construction;
3. City and County of Denver's parallel Delgany Interceptor and Storm and Sanitary Sewer Separation projects to be constructed;
4. City of Westminster's Big Dry Creek Plant expansion now being designed;
5. Metropolitan Denver Sanitary Disposal District No. 1 (MDSDD No. L) central plant expansion now under construction;

6. MDSDD No. 1 sludge disposal plan now being finalized for funding;

7. New regional plant and interceptors for Littleton and Englewood now under construction; and

8. MDSDD's Platte River II Interceptor now under construction.

The Clean Water Program (208 Plan)

The Denver Regional Council of Governments (DRCOG) was designated the 208 study agency for the Denver area to address the complicated water pollution problems in this highly urbanized area.

The DRCOG 208 study, named the Clean Water Program, has evaluated the national goals and their attainability in the Denver area with respect to financial, environmental, social and economic impacts. It has also attempted to determine technical solutions to regional environmental problems and recommended a management system for implementing the clean water plan. The draft of the 208 plan was released in April by DRCOG. The final plan must be developed and approved by July 1977.

As an integral part of the work effort of the 208 plan, population allocations and a land-use plan have been developed by DRCOG, as well as a set of recommended treatment plant funding priorities and levels of quality for plant effluents. An assessment of the non-point source problem as it affects meeting the national goals is also included in the plan.

Since this information is germaine to the individual facility plans and since EPA must review and approve the 208 plan under National Environmental Policy Act criteria, this EIS will also cover relevant portions of the 208 plan.

THE NEED FOR THIS EIS

As mentioned briefly, EPA is concerned about the piecemeal manner in which its NEPA reviews of earlier projects have proceeded. Regional or secondary impacts simply could not be adequately discussed at the project level.

It now appears time to prepare a regional environmental impact statement which analyzes various regional issues associated with waste water facility plans. The preparation of a regional environmental impact statement will expedite Federal funding in the longer term and substantially reduce the need for environmental impact statements on a project-by-project basis. More importantly, the approach will permit local governments and the citizenry to address these significant regional issues.

Air Quality and Water Quality Planning Consistency

The regulatory aspects of EPA's activities under the Clean Air Act relating to transportation control plans to achieve air quality standards may not require a NEPA evaluation. However, EPA has come to realize that activities in different media programs (here air and water pollution control) need to be consistent.

The Denver Air Quality Control Region (AQCR) is currently in violation of ambient air quality standards for carbon monoxide, particulates, and ozone. A transportation control plan (TCP) has been adopted by the Colorado Air Pollution Division, Department of Health and EPA. Implementation of the various control strategies to date has been very limited and air quality standards will continue to be violated for at least several years even with controls.

A court decision (NRDC vs EPA) required EPA and the States to upgrade their State Implementation Plans to attain air quality standards, and to develop plans to maintain standards once attained. Thus the present TCP for Denver will have to be improved to provide for maintenance of air quality. At present, the Air Quality Maintenance Plan for Denver AQCR is being analyzed. The latest available modeling indicates that it is very doubtful that additional strategies, which may be added to the original TCP, would result in attainment of air quality standards by 1983 because of existing emissions and future population growth would offset their effectiveness.

The principal source of both carbon monoxide and ozone (formed from hydrocarbon emissions) is the automobile. This is why the transportation control plan has been developed for the Denver AQCR. Using historical trends, we can be reasonably confident that there is a linear relationship between additional population and increase in vehicle miles travelled (VMT).

In regard to facility planning, the environmental issue of note becomes this: to what extent does the population growth planned in for sewage treatment plant and interceptor capacity relate to further VMT growth in the metropolitan Denver area? Is the planning for treatment plant capacity consistent with AQMA plans? Among other, probably more acceptable, strategies the Clean Air Act does provide for land-use controls if necessary, to achieve and maintain air quality standards. Thus it was felt necessary to look at projected population growth in terms of a) total growth, b) the distribution of this growth and to a certain extent c) how future development patterns would be organized to determine its impact on air quality. Such projections for growth, size, and distribution are, of course, an essential element of facilities planning for sewers and wastewater treatment plants. EPA feels that its approach in these two areas of environmental protection must be consistent.

Impacts of Growth on Achieving Water Quality Standards

Planning for future growth means, of course, that more sewage and other forms of water pollution must be accounted for and controlled. In particular, non-point sources (those diffuse pollution sources not developed or relased at a definable single point on a stream or lake —e.g. stormwater runoff, agricultural return flows, lawn watering, car washing, etc.) must be accounted for in calculating the total impact on stream quality. Estimates of future growth must evaluate not only the incremental burden of domestic usage to streams, but the added non-point source growth increments as well.

In order to properly plan for wastewater treatment facilities, one must know:

a. What degree of treatment is necessary at the plant.

b. What are the other sources on that stream reach which also contributing to the problem.

c. How can they be controlled and

d. What is the likelihood and cost of attaining stream standards required under the Act.

The 208 study in progress by DRCOG has been under development at the same time as the preparation of the facility plans. However, decisions on facility plans such as degree of treatment, type of treatment, location, population impacts, etc., must have the benefit of the overall 208 study. This EIS is an attempt to bring together these disparate studies for EPA's evaluation of the total water quality picture for the Denver metropolitan area.

Relationships of Wastewater Treatment Plant Organization

Sixteen wastewater treatment projects are undergoing planning or construction at this point in time in the contiguous Denver metropolitan area. Virtually all of the separate facilities planning is interrelated in some fashion. Decisions on the smaller upstream plants (So. Lakewood, Cherry Creek, Clear Creek, Sand Creek, So. Adams) invariably involve maintenance or development of an upstream facility versus connection with a downstream facility (Denver Northside, Metro, etc.). In some cases (Westminster, Lower South Platte) potential decisions may involve a redistribution of flows between the separate districts. It is thus important to consider these individual options, together and a common point in time. It may also be possible to develop an overall policy consistent with other needs of the State (water rights, re-use, instream benefits) concerning satellite versus centralized treatment.

Prime Agricultural Land Losses

This is a special land-use problem that is not only a regional problem, but a national one. The Council on Environmental Quality, rightly concerned with the problem, commissioned a special study to analyze the impacts of urban growth on the nation's farmlands. The study demonstrated that the prime agricultural land is rapidly being converted to urban uses. In a qualitative way, EPA has been aware of similar problems in the Denver metropolitan area. Virtually all new housing development in the metropolitan area uses some form of agricultural land. The land could vary from rangeland to dryland farming, to irrigated farmland.

The relationship between this loss of agricultural lands and facility planning is as follows: The projections used in facilities planning of how much new population and where population will go will have a strong effect on the amount of farmland lost.

This is one more area in which EPA and other agencies have little information with which to make a decision. Facility plans to date have not catalogued how much of the various categories of farmland will be eaten up by the projected developments. Therefore, EPA cannot estimate the magnitude of the problem except in general terms. This EIS will investigate on a regional level, how many of the various categories of farmland acreage will be lost to projected developments, how critical in terms of the overall State and national farming economy the loss of these lands are, and whether any specialty crops are involved that cannot or are not likely to be grown elsewhere. Only with this information can a set of reasonable strategies be offered for mitigating such land losses in facility planning.

Sensitive Environmental Area

In planning for future growth, planners need to be aware of the potential impact of new population on environmentally sensitive areas unsitable for development. Such a list of features would include:

- unusual geological features
- archaeological features
- historical features
- floodplains
- marshland/wetlands
- wildlife habitat areas
- natural vegetation areas
- steep slopes/unstable soils

The first problem is to recognize the commonality of these items from one service area to another. Many of the items in a given service area represent only a fraction of the total resources. There is a need to look cumulatively at the entire Denver metropolitan region to assess how vulnerable these resources are. The EIS in conjunction with the 208 information will be developing an environmental sensitivity inventory that can give EPA an overall picture of the situation. Each of the items above fall under different spheres of control and would have to be handled differently. As a policy, EPA could insist that maximum protection under current law be given to areas identified as important. Hopefully, the EIS will be able to develop a comprehensive strategy to deal with these areas in all facility plans.

Socioeconomic Impacts

This is an area that has received very little attention in past EIS efforts on wastewater facilities. The EIS will attempt to identify any sociological or economic impacts both beneficial and adverse, that could occur because of the overall Federal investment pattern of construction grants in the Denver metropolitan area. The EIS will pay particular attention to the problems involving suburban districts versus the central city facilities and the potential influence that this Federal Funding program may have on urban form.

Land Treatment and Reuse in the Metropolitan Denver Area

EPA is required to consider land application and reuse of wastewater as potentially benefitical ways of achieving water quality standards and attaining other valuable environmental objectives (farmland protection use of nutrients, etc.) Until now, land treatment has received limited evaluation in facility plans. Land treatment involves the discharge of treatment plant effluent onto the land surface where percolation through and interaction with the soil removes pollutants. The first comprehensive water quality management study (called the 303 (c) plan) for the Metropolitan Denver area eliminated land treatment because of the high cost. The 208 study is reevaluating the potential for land treatment and reuse in the study area.

Because of the scarcity of water in Colorado for all uses (mumicipal, industrial, agricultural), interest has grown in many Colorado communities in instituting some form of water reuse. Particularly in the fast growing areas, municipalities may be able to increase their domestic water supplies through an arrangement of "first use" by municipalities and use of wastewater effluent by agricultural concerns. Colorado water rights laws dictate to a large extent what kinds of "reuse" schemes are available to communities.

The effects on water quality may be beneficial, but it is not necessarily true in every case. Streamflows can be depleted as well as augmented. It will depend to a large extent on the type of reuse system involved. The issues involving plant organization are in some ways related to this issue. In this EIS, then, EPA will define the types of potential reuse systems, the specific situation as it occurs in Colorado, and impacts likely to occur for different systems. Eventually, decisions on the most beneficial types of reuse from a water quality standpoint may be influential in determining the satellite-regional plant arrangements.

THE OPTIONS AVAILABLE IN THIS EIS

The foregoing are issues that EPA identified that suggested a need for a regional EIS. This EIS also identifies and evaluates to the extent possible any other relevant and significant issues that have been concerned in the process of developing this EIS. The EIS will also identify on a cumulative basis, direct impacts common to all facility plans. This regional EIS on 8 wastewater facilities and the Clean Water Program is not an attempt to define the environmental "carrying capacity" for the Denver Metropolitan Area. One set of population and land use assumptions are utilized for the evaluation of the various topics. Consistent with the DRCOG forecasts and the Clean Water Program, a population of 2.35 million is assumed for the year 2000 as is the adopted regional land use plan.

Recommendations for mitigation as a result of the analyses in this EIS could involve changes to the facility plan or potential requirements on grants for design and construction. Table 1 depicts a matrix of possible areas of facility plan development that could be affected by the different impact (issue) analyses.

THE OBJECTIVES OF THIS EIS

As an overall perspective, the following general objectives were identified for this EIS based on the above discussion.

(a) To define and assess the environmental impacts of the eight Denver metropolitan wastewater facility plans and the secondary impacts of the 208 Clean Water Program.

(b) To define EPA policy and decision options for assurance of consistency between EPA'a Air and Water Programs and the goals of NEPA, including the options for mitigation of adverse secondary impacts.

(c) To stimulate public discussion about "desirable" environmental goals for the Denver metropolitan area, with emphasis on the relationship of EPA's construction grants program to other Federal State, Regional and local governmental programs.

Table I-A. FACILITY PLAN REGIONAL EIS ENVIRONMENTAL ISSUES AND EPA DECISION OPTIONS*

	REGIONAL ENVIRONMENTAL ISSUES						
OPTIONS AVAILABLE TO EPA UNDER THE CONSTRUCTION GRANTS PROGRAM	Air Quality Impact	Water Quality Impact	Plant Organization	Agricultural Land Loss	Sensitive Environ-Mental Area Impacts	Socio-economic Impacts	Regional Alternatives
Treatment Plant Capacity and Timing	X	X		X			
Alternative Systems		X	X				X
Type of Treatment (Design)		X	X		X		
Extent of Treatment (Levels)		X	X				
Location of Plants and Interceptors	X	X	X	X	X	X	X
Special Grant Requirements for Step II and Step III Projects	X	X		X	X	X	

* X indicates where there may be a likely decision option.

The latter point deserves some further elaboration. EPA has extensively coordinated the preparation of this EIS with various state, local and federal agencies. Some of these agencies have performed or have embarked on studies which are pertinent to this EIS and the issues it addresses. For example, this EIS makes extensive use of information, data, and analysis developed by the Denver Regional Council of Governments and its consultants for the 208 planning effort. The U. S. Department of Housing and Urban Development has initiated an EIS on its FHA housing program for Denver, and the U.S. Bureau of Land Management will soon complete a revision to its draft EIS on the proposed Foothills Water Treatment Plant. In terms of growth related environmental issues, the EPA EIS emphasizes areas of EPA responsibility such as air and water quality, and is intended to supplement work by other agencies. Thus it is hoped that this EIS will help provide a focus for confronting growth related environmental issues of much concern to the State of Colorado and the citizens of the Denver region.

REPORT ORGANIZATION

This report is organized into a progressive sequence of discussions addressing issues which EPA must resolve. EPA must take a series of decisions about the most effective way to spend resources (grant funds). These resources, though large, are limited. EPA has several options concerning the level of treatment of wastewater, which pollutant discharges are most important, what wastewater treatment plan flow capacities are most appropriate, what standards are appropriate to meet water-use goals and others. The environmental consequences of these options are an integral part of this draft Environmental Impact Statement. This draft EIS, together with the public review and input it will stimulate, will form the basis for a final EIS which will address the environmental effects of possible EPA actions as best as can be determined.

The following section of this report discusses the current environment in the Denver region. What environmental problems now exist or are anticipated, giving existing trends, are also addressed. Next, the project proposals which have been or are anticipated to be submitted to EPA are presented and discussed. These actual and anticipated proposals are then organized into three broad alternative strategies or courses of action which EPA may take. Subsequent discussions in this draft EIS plus public review and input will modify and evolve one of those alternative strategies into a course of action best suited for the maintenance and inhancement of the environment. The discussions of impacts, means of mitigating impacts, impacts that can't be avoided, short-term uses of the environment versus long-term environmental productivity, and irreversible commitments of resources are presented in this draft EIS as a first step in the evolutionary process.

II. The Existing Environment

SECTION II

THE EXISTING ENVIRONMENT

SITUATION AND DESCRIPTION OF THE DENVER REGION

The study area for this EIS is shown on Map A*. The semi-arid Denver region is located at the approximately 1,600 m (5,280 ft) high western edge of the high plains province of Colorado. This portion of the Great Plains slopes upward 585 m (1,930 ft) for almost 300 km (186 miles) from the 1,020 m (3,350 ft) high eastern state boundary to the abruptly rising foothills at the base of the Rocky Mountains. Relief is characterized by rolling prairie with some hills and ridges intersected by level flood plains along the generally northeast flowing watercourses of the Platte River drainage. The South Platte River and Cherry Creek flow through the heart of Denver.

Approximately 1.5 million people (1975) live in the region (Reference 126). Regional growth reached a peak rate of 5.5 percent per year in 1972-73 and has since declined to a rate close to the 1960-70 average of 2.6 percent. Population distribution patterns are changing as the central city continues to lose population to the suburbs (see Map B). Residential areas and their service facilities surround the commerce areas with densities decreasing with distance from the urban core to the suburban/rural edge of the region.

Denver is the state capital and is the major Federal administrative center for the Rocky Mountain States. Government employment is considerable with thousands of people employed by the state, the Rocky Mountain Arsenal and other government facilities. Transportation industries such as aviation, trucking and railroads are of major importance to the region's economy due to Denver's crossroads situation for many transportation routes. Commercial and industrial enterprises are concentrated in the urbanized areas with many of them located in the Denver downtown area and along major streams. Mineral extraction industries are also found along the region's streams. Agricultural activity is a significant part of the region's economy.

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*All maps referred to can be found in the Map Folder supplied with this report.

ENVIRONMENTAL SENSITIVITIES

EPA's purpose for this EIS is to examine the effects and issues of growth in the Denver area so that it might determine whether or not it should contribute to the accomodation of this growth through its wastewater funding programs. Also, EPA must consider its administrative responsibilities in terms of the regional environment and promote programs and strategies for dealing with physical environmental problems such as air and water quality. To examine these effects and issues, a mass of data and information on the Denver area for this EIS has been edited to emphasize the major characteristics of the region that may affect or be affected by the proposed projects and by growth. A more lengthy and detailed presentation of general physical, biological and cultural characteristics of the region can be found in Appendix A.

Regional Climatology

Appendix Table A-1 provides a specific data summary for the following general discussion.

The Denver region, lying at the western edge of the Great Plains near the Rocky Mountain foothills, is in an area of transition between the climate of the plains and that of the mountains. The region is situated within an area having, overall, a high-altitude, continental climate. Locally, the region's climate is that of semi-arid steppe.

Temperatures are generally moderate. The growing season is approximately five to six months long. Precipitation is relatively light, with a large portion falling during the April-September growing season. Much of the summer precipitation occurs as a result of thunderstorm activity, and heavy thunderstorms in the eastern foothills and plains area occasionally cause flash floods. Snowfall is generally not heavy. Extensive flooding caused by snowmelt in the nearby mountains occurs only at times when there has been either a heavy accumulation of snow or sudden high altitude warming. The generally low relative humidity is a major factor in the region's somewhat high annual evapotranspiration rate which is twice the average annual precipitation.

Denver experiences high winds. The wind data presented in Appendix Figure A-1 for Stapleton Airport on the northeast edge of Denver are representative of the region. Denver also experiences infrequent and often destructive "Chinook" winds from the northwest during fall through spring. Chinooks with velocities of up to 54 meters per second (120 mph) blow down from high-elevation westerly winds warmed by compression during their rapid descent through the shallow layer of cool air covering the plains. The sudden rises in temperature resulting from these gusty winds exert a moderating influence on winter temperatures. Chinooks are experienced in a 24-32-km (15- to 20-mile) wide zone along the foothills. Although little information has been published which identifies areas of greatest wind velocities, it is recognized that winds during Chinook events are 3-5 mph higher along the bottoms of the stream valleys than in the surrounding areas. Therefore, wind damages are also generally greater in the stream valleys. Ridges which experience higher than average wind velocities during Chinook events are shown on Map C. Construction activities are generally restricted during Chinook events and wastewater treatment processes involving spraying are generally curtailed (Reference 126, 413).

During the winter and spring, early morning, local radiation fog conditions are common along the low-lying stream valleys, particularly near irrigated parklands and farms, large bodies of water, and wastewater treatment plant lagoons. Because many of the major transportation routes are situated in the stream valleys where most fog-contributing water sources are located, fog conditions often impede commuter traffic.

Air Quality in the Denver Region

The following discussion will first present aspects of the climate in the Denver region which affect air pollution levels. Next, short discussions of health effects and effects on agricultural crops are presented. The next sections will discuss current air quality and the sources of air pollutants. The last section in the air quality discussion presents some available on public concerns about air quality.

Climatic Conditions--

Air quality in the Denver area is influenced primarily by the South Platte River Valley and its associated drainage winds that move down the valley to the northeast during the evening and then reverse approximately mid-morning with upslope motion occurring during most of the remainder of the daylight hours. As the air flows across the city, pollutants generated at the surface are transported back and forth over the area increasing and decreasing the pollutant concentration. Fortunately, Denver's location on the east side of the Rockies means that the containment of a pollutant cloud during generally prevailing westerly winds does not occur as, for example, happens in Los Angeles.

Solar radiation plays an important role in determining air pollution potential. The ultraviolet component of sunlight is the driving force that initiates the chemical reactions necessary to produce photochemical smog. Denver, at its "mile high" altitude, receives a higher amount of ultraviolet radiation because the thinner atmosphere doesn't filter out as much ultraviolet radiation.

Normally, the temperature of the air decreases with height above ground surface. When the opposite occurs, or temperature decreases with height, upward movement of cold surface air is restrained by the "lid" of warmer air aloft. This condition is called an inversion. The altitude or depth of this inversion, in hundreds or thousands of feet, determines the volume of air in which air pollutants are mixed and how concentrated they become. Denver is very unusual because no city of comparable size in the nation has a lower morning inversion or a higher afternoon inversion. This means that air pollutants emitted in Denver's morning rush hour are trapped in a very thin layer of air. However, by afternoon, the volume of air has increased drastically as the inversion rises, and pollutants are thereby greatly diluted.

Effects of Air Pollutants on Health--

The Clean Air Act Amendments of 1970 mandated that minimum standards of air quality be set to protect the public health and welfare of the population at large. The law requires that primary standards be set to protect the public health with an adequate margin of safety, and that secondary standards be set to protect the public welfare. Effects on public welfare are concerned mostly with plant and property damage.

The EPA after a great deal of research set standards for five pollutants. These are Carbon Monoxide (CO), Photochemical Oxidants (usually characterized as Ozone), Sulfur Oxides (SO_x), Nitrogens Dioxide (NO_2), and Total Suspended Particulates (TSP). Standards for all but Sulfur Oxides are shown in Table II-A, the health effects of these pollutants are discussed below. Sulfur Oxides are not discussed in this EIS as they are not currently a problem in the Denver region.

Carbon Monoxide--Carbon monoxide (CO) is a colorless, odorless, tasteless gas commonly found in our urban atmosphere in concentrations that can be harmful to people. It is a by-product of combustion, and the greatest single source of this pollutant is the automobile.

Carbon monoxide is inhaled through the lungs and enters the blood stream by combining with hemoglobin, the substance that normally carries oxygen to the cells. CO combines with hemoglobin much more readily than oxygen does. The result is that the amount of oxygen getting to the tissues is drastically reduced in the presence of CO, and this can have a profound effect on health. CO also impairs heart function by weakening the contractions of the heart which supply blood to the various parts of the body. The effect of this on a healthly person is to reduce significantly his ability to perform

TABLE II-A. NATIONAL AMBIENT AIR QUALITY STANDARDS[a]

Pollutant	Averaging Time	Primary Standards	Secondary Standards
Particulate matter	Annual (geometric mean)	75 μm^3	60 μg/m^3
	24 hour[b, c]	260 μg/m^3	150 μg/m^3
Carbon monoxide	8 hour[b]	10 mg/m^3 (9 ppm)	10 mg/m^3 (9 ppm)
	1 hour[b]	40 mg/m (35 ppm)	40 mg/m (35 ppm)
Nitrogen dioxide	Annual (Arithmetic mean)	100 μg/m^3 (0.05 ppm)	100 μg/m^3 (0.05 ppm)
Photochemical oxidants	1 hour[b]	160 μg/m^3 (0.08 ppm)	160 μg/m^3 (0.08 ppm)
Hydrocarbons (nonmethane)	3 hour (6 to 9 a.m.)	160 μg/m^3 (0.24 ppm)	160 μg/m^3 (0.24 ppm)

[a] The air quality standards and a description of the reference methods were published on April 30, 1971, in 42 C.F.R. 410, recodified to 40 C.F.R. 50 on July 1, 1975.

[b] Not to be exceeded more than once per year.

[c] State standards for particulate matter:
24 hour, 150 μg/m^3; Annual, arithmetic mean, 45 μg/m.

exercise, but in a patient with heart disease, who is unable to compensate for the decrease in oxygen, it can be a life-threatening situation. A person who has a heart attack in the presence of heavy carbon monoxide air pollution is more likely to die than if the attack had occurred in clean air. And carbon monoxide is also harmful to person who have lung disease, anemia, or cerebral-vascular disease.

Carbon monoxide can also affect mental function at relatively low concentrations of 30 parts per million (ppm). Visual perception and alertness can be affected.

Ozone--Photochemical oxidants are responsible for a number of health effects in humans. They can affect the lungs and eyes. They may result in eye irritation with the familiar symptoms of tears and inflammation. At certain concentrations they have been shown to impair the performance of athletes, and to affect persons with asthma.

Ozone, the main constituent of photochemical smog, is a severe irritant to all mucous membranes, and its main health effects are on the respiratory system. It is verturally intolerable at levels of 1 part per million. At considerably lower concentration (0.1) to 0.2 ppm) which often occur in the air of many American cities, ozone in conjunction with other photochemical oxidants causes a variety of health effects which are aggravated by exercise. Ozone also has an increased effect on respiratory function in the presence of sulfur dioxide.

Nitrogen Dioxide--Oxides of nitrogen usually originate in high-temperature combustion processes, such as in auto engines, and to a lesser extent in chemical plants.

Although measurement of this pollutant in the atmosphere is difficult, experience has shown that in various forms, oxides of nitrogen can affect humans as well as materials and vegetation.

Based on occupational exposures to nitrogen dioxide by firemen, welders, silo fillers, miners, chemists, and other industrial workers, we know that a high concentration of this pollutant can be fatal to humans. At lower levels of 25 to 100 parts per million, it can cause acute bronchitis and pneumonia.

The group of pollutants known as nitrogen oxides also can affect lung tissue and lower the resistance of laboratory test animals to influenza. Scientists suspect the same effect may occur in humans. In one study of schoolchildren living near an industrial plant producing nitrogen dioxide, an increase in respiratory disease was noted.

Oxides of nitrogen also can react with hydrocarbons, in the presence of sunlight, to form photochemical oxidants which, as noted elsewhere, can affect human lungs and eyes as well as cause respiratory irritation.

Total Suspended Particulates--Total suspended particulates (TSP) is a term for the measurement of all particles in our air, including soot, mists, and sprays. TSP includes a wide range of non-toxic materials such as dust and dirt, and many other materials that we know or suspect to be toxic, such as beryllium, lead, asbestos, certain hydrocarbons which may be carcinogenic, suspended sulfates and nitrates, and possible, radioactive elements.

The amount of toxic materials in our air will vary geographically, depending on the man-made and natural sources in a particular area. To date, few studies have been conducted on the health effects of individual particles because of the wide range of differences in the makeup of particulate concentrations. Particulate matter is studied for the most part as a single contaminant, and most studies relate particulate concentrations to death, respiratory illness, and breathing problems in urban industrial areas where energy supplied by fossil fuel consumption is a major concern.

The effects of particulate air pollution on health are related to injury to the surfaces of the respiratory system, that is, to the linings of the lungs and throat. Such injury may be temporary or permanent. It may be confined to the surface. However, by weakening resistance to infection, such pollutants may affect the entire body adversely. Chemical carried into the lungs by particulates, for example, may cause cancer to develop on the lung lining, which then may spread throughout the body and prove fatal. Inhaled lead particulates may cause lead poisoning--manifested by nervous and blood symptom--while causing very little damage to the lung itself.

In studies of air pollution in London and New York City, a rise in the number of deaths has been recorded when both smoke and sulfur oxides levels were high. Studies in Buffalo and Nashville also showed increased death rates, particularly among older persons, where combined pollution from particulates and sulfur oxides were recorded. Eye irritation from dust particles also can be a problem in many areas.

Effects of Air Pollutants on Crops--

The effects of air pollutants on crops have been subject to investigation for nearly thirty years. However, the state of knowledge is not as complete as for effects on people. Pollutants can damage crops by stunting growth and by causing physical changes of a type similar to those caused by pests and plant diseases. The stunting of growth reduces the yield per acre and the visible damage reduces the marketability particularly for crops destined for supermarket shelves.

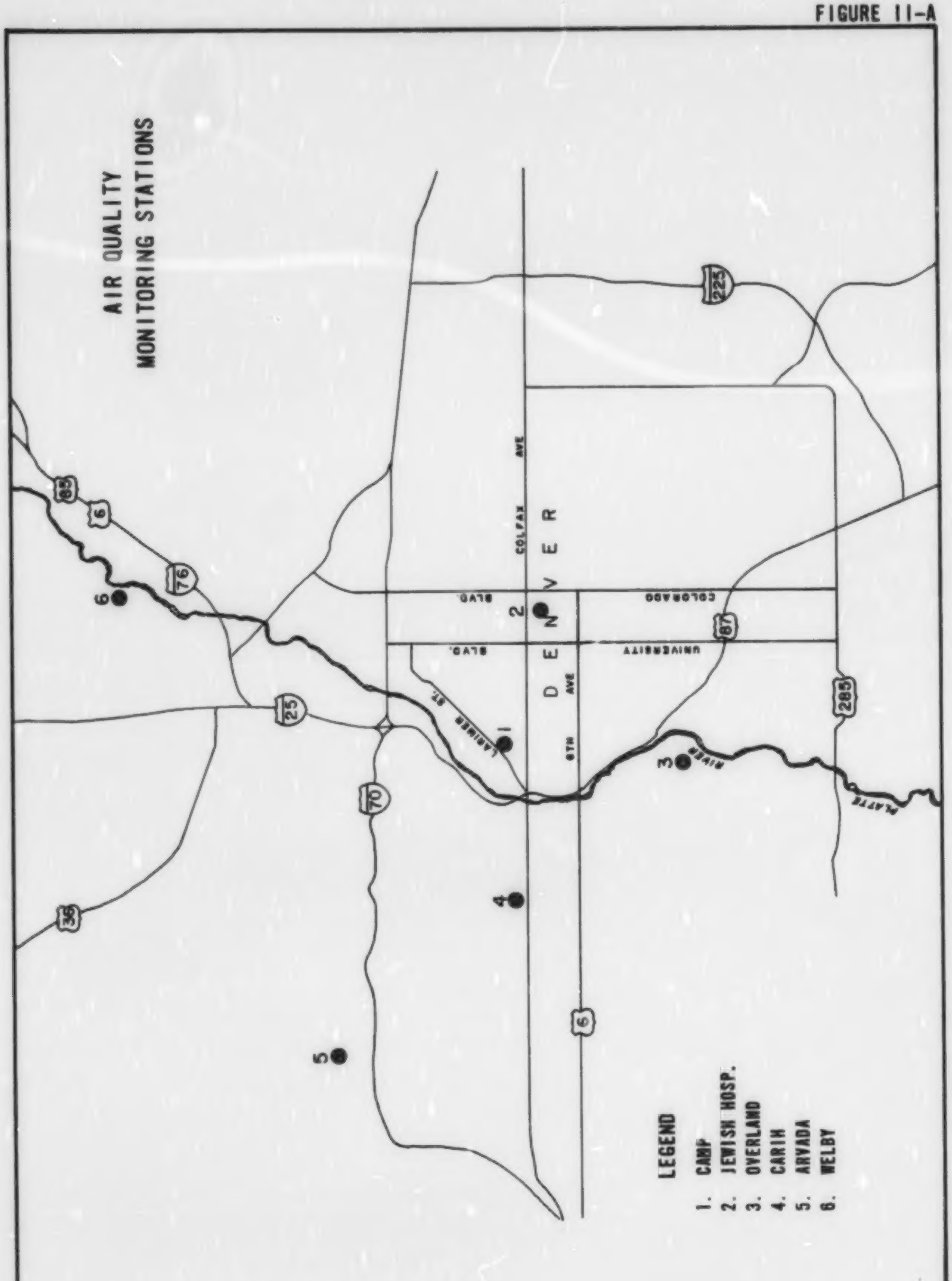
The air pollutants of major interest nationally are oxidants, sulfur dioxide, and fluorine compounds. The last two pollutants are characteristic of certain type of point sources and are not of concern at this time in the Denver region. Oxidants, primarily ozone, are the pollutants of primary concern in the Denver region. Crop damage caused by zone is not a straightforward function of ozone concentration. The degree and type of damage depends on the crop as well as climate. Different varieties of crops, e.g. different hybrids of corn, having varying sensitivities to ozone. Of two varieties of corn exposed 50% of the time to oxidant concentrations of 8 parts per hundred million (pphm) or more during daylight hours, one was found to have little significant damage, while the other variety had significant reductions in the number and size of ears produced (Reference 993). The crops most sensitive to oxidants are alfalfa, barley, beans, clover, hay, oats, potatoes, rye, soybeans, sugarbeets, all types of citrus, and leafy vegetables. As many of these crops are grown in the Denver Region, air pollutant effects on agricultural productivity are of potential significance.

Existing Air Quality--

Since 1974, the Colorado Department of Health has had six continuous monitoring stations in operation in the Denver area. The location of these monitoring stations is shown in Figure II-A.

Figure II-B shows the number of days that CO standards were violated in 1974 at these monitoring stations. The CAMP station is in the heart of Denver, whereas the Welby Station is in a very rural location.

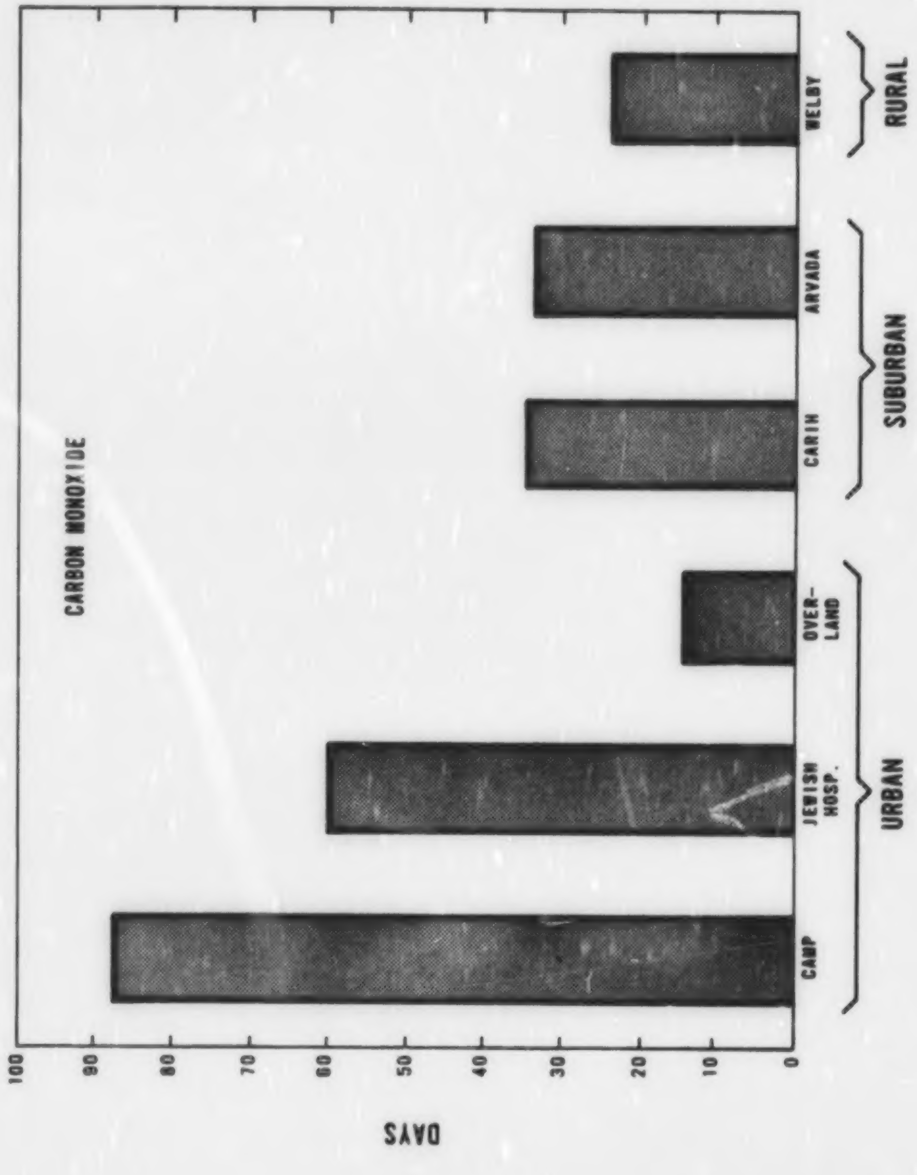
FIGURE II-A



AIR QUALITY MONITORING STATIONS

LEGEND
1. CAMP
2. JEWISH HOSP.
3. OVERLAND
4. CARIH
5. ARVADA
6. WELBY
DENVER
COLFAX AVE
6TH AVE
COLORADO BLVD.
UNIVERSITY BLVD.
LARIMER ST.
PLATTE RIVER
225
85
6
76
87
285
25
70
36
6
1
2
3
4
5
6

NUMBER OF DAYS IN 1974 STATIONS RECORDED LEVELS EXCEEDING STANDARD



Annually, the winter season is the worst for CO. This is because the inversion heights are lower and the CO is trapped in more concentrated form. Figure II-C shows the annual trend in 8 hr. CO violations for 1974.

During an average day, CO concentrations tend to peak during the traffic rush hours in the morning and afternoon. Figure II-D demonstrates a typical "CO day" at the downtown CAMP station. Since CO is directly emitted from car exhausts (the principal source of CO in the Denver region is the automobile) concentrations are highest along major streets and busy intersections. These areas of high CO concentrations are often referred to as "hot spots."

Ozone is not directly emitted by sources, but is formed from hydrocarbon and NO_x emissions by the action of sunlight. Since time is required for the ozone to form, it occurs in the highest concentrations down-wind from the sources of the hydrocarbons as shown in Figure II-E.

About 70% of the hydrocarbon emissions in Denver come from motor vehicles, and about 30% of the hydrocarbons come from stationary sources like petroleum refineries, gas stations, and dry cleaners.

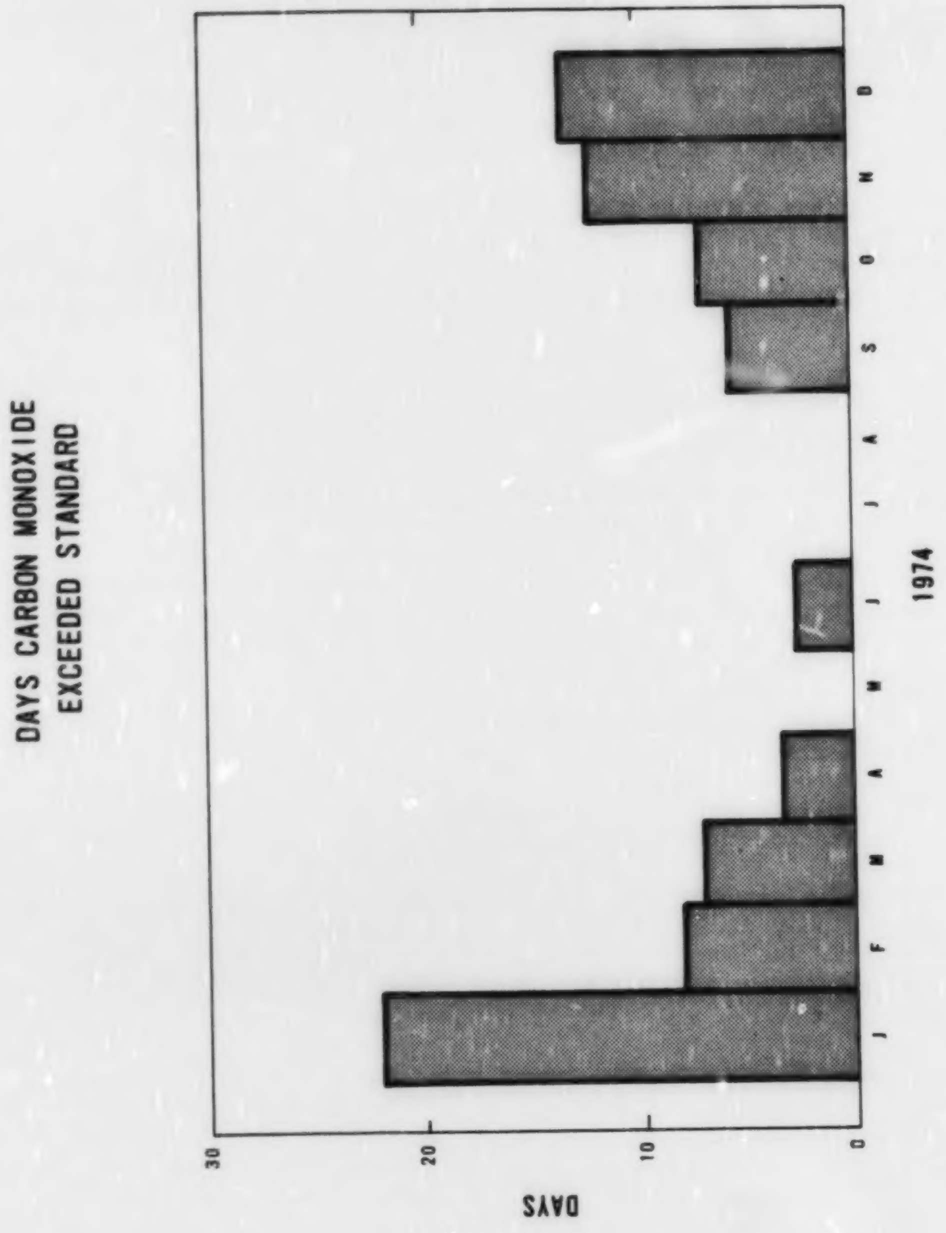
Unlike CO, Ozone because of the way it is formed tends to record highest values in the suburbs. This occurs because during days when wind speeds are low the hydrocarbons and oxides of nitrogen will have formed Ozone about the time the pollutant cloud has drifted over the suburbs and into rural areas. This trend is shown in Figure II-F. In 1974 every monitoring station had a significant number of days when the ozone standard was exceeded.

Ozone tends to be a problem in the summer because larger quantities of ultra-violet radiation from more intense summertime cause more ozone to be formed. Figure II-G shows this summertime peak in ozone. This characteristic is in direct contrast with the annual distribution of CO concentrations shown in Figure II-C.

Particulate matter is defined as any material, except water, that exists in a finely divided form as a liquid or solid. Since Denver lies in an arid section of Colorado, much of the particulate matter is generated from unpaved roads, construction operations and natural soil erosion.

Particulate levels in the Denver area also exceed the standards regularly. Fourteen of the twenty-two existing particulate monitors in Denver currently record violation of the ambiant annual particulate standard. Depending on the location, these levels vary from slightly over the standard (74 mg/m^3) to almost double the standard in 1974.

FIGURE II-C



DAYS CARBON MONOXIDE
EXCEEDED STANDARD

FIGURE II-D

CARBON MONOXIDE LEVELS COMPARED WITH TRAFFIC VOLUME

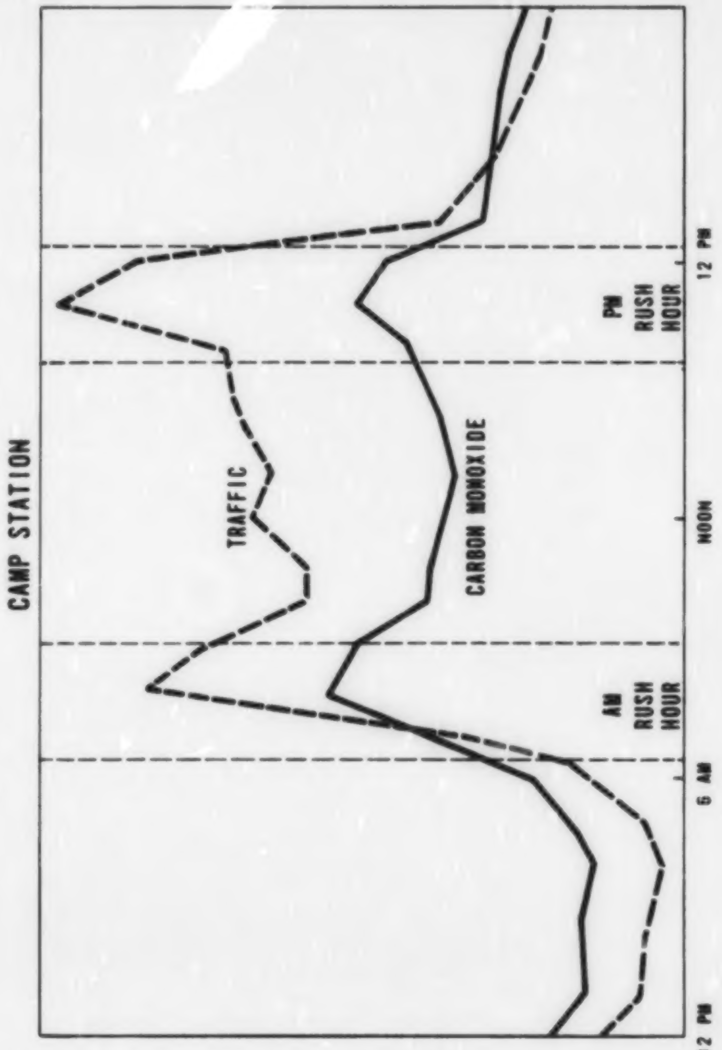
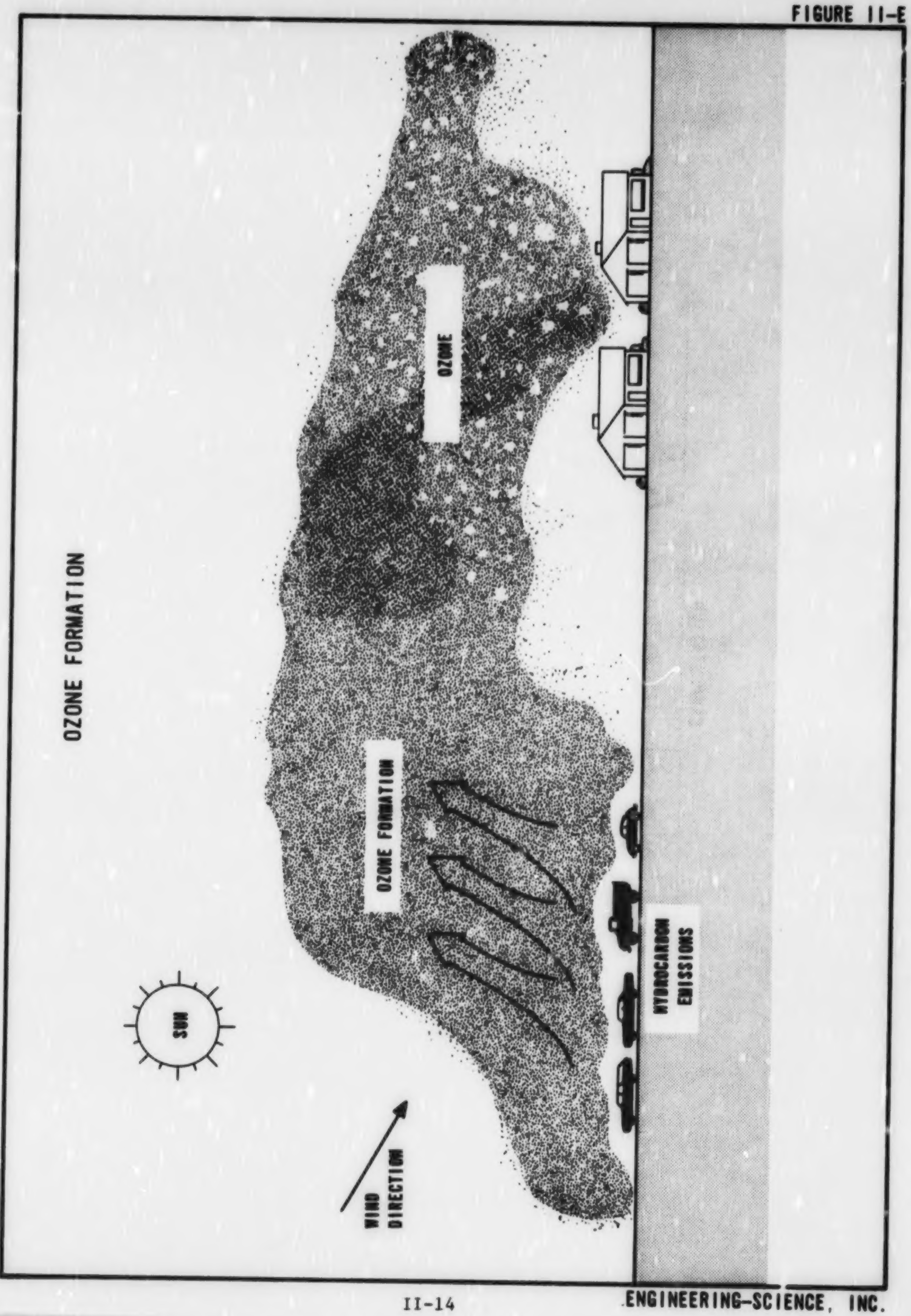


FIGURE II-E



OZONE FORMATION

SUN
WIND DIRECTION
OZONE FORMATION
OZONE
HYDROCARBON EMISSIONS

FIGURE II-F

NUMBER OF DAYS IN 1974 STATIONS
RECORDED LEVELS EXCEEDING STANDARD

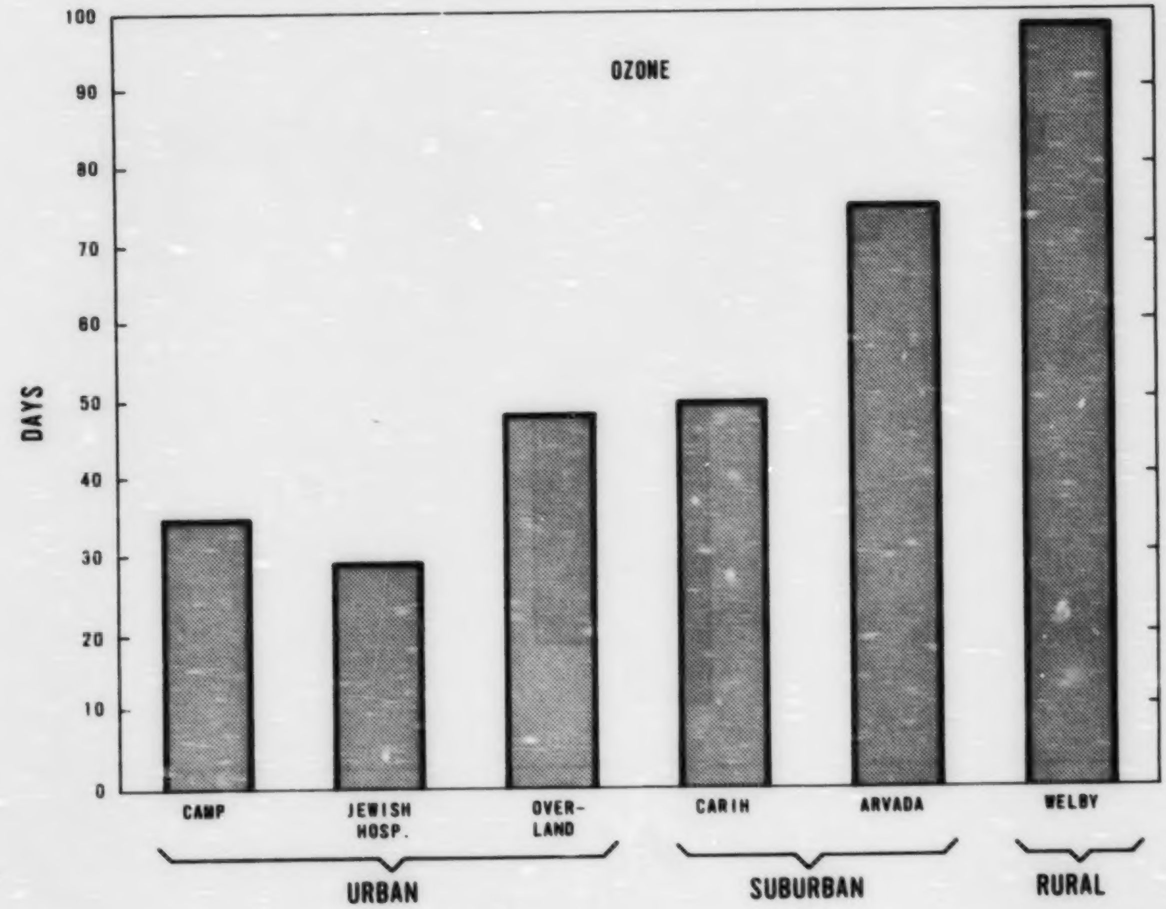
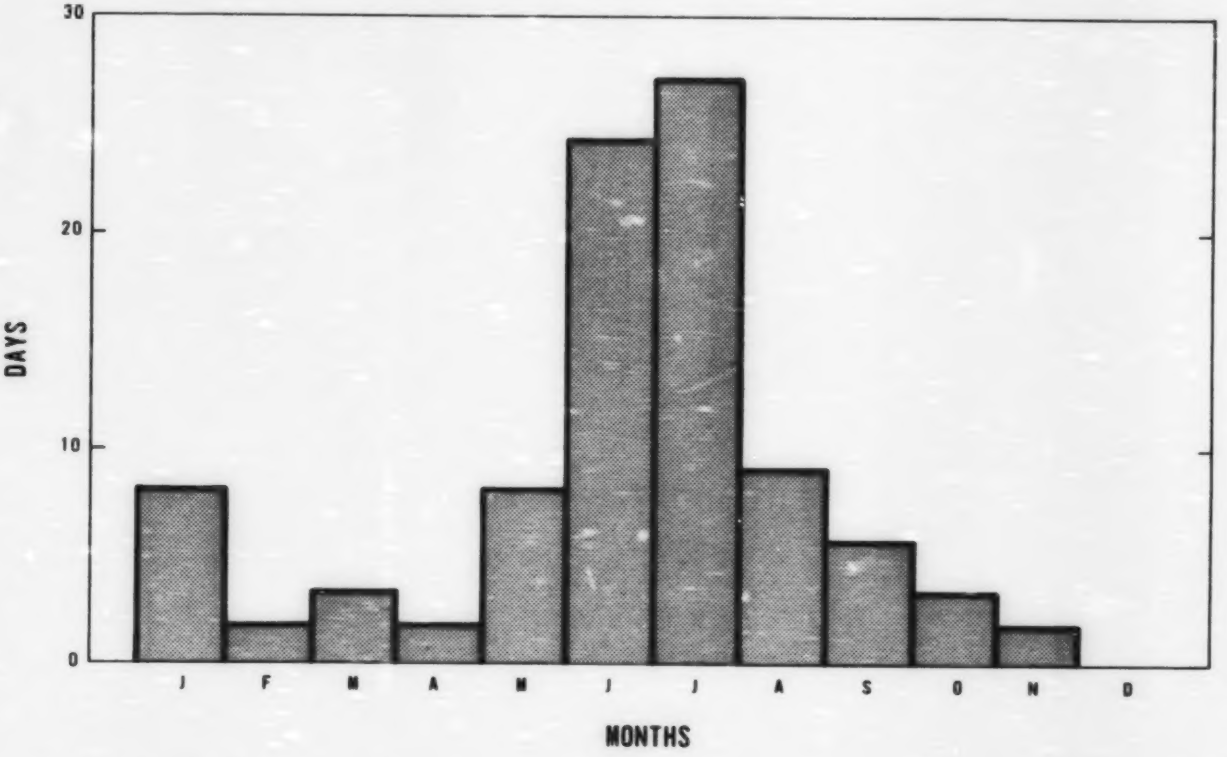


FIGURE II-G

DAYS OZONE
EXCEEDED STANDARD



The Denver region has one nitrogen dioxide monitoring station which is located in the central downtown area where NO sources are the densest. Even with all the photochemical acitivity frequently experienced during the summer months, no violation of the Federal annual average NO_2 concentration (0.05 ppm) was reported in the Denver metropolitan area. Since NO_2 is formed from NO emissions in the same photochemical process that forms Ozone, exceedances of the NO_2 standard may exist in the suburbs of Denver where presently no NO_2 monitor exists.

Table II-B summarizes the exceedances of the CO and Ozone standards for 1974 and 1975. 1974 data was used for the above discussion, however, 1975 data is similar. The frequency and magnitude of violations decreased somewhat in 1975, however, average wind speed also decreased. The decreases in air pollution are not thought to be caused by any reduction in emissions between 1974 and 1975.

Spring and summer temperature increases generally accelerate the biological processes used in some wastewater treatment facilities which can intensify any potential odor problems. The same inversion and low wind conditions trapping smog over the region also prevent adequate dispersal and dilution of odors from point sources.

Pollutant Emissions in Denver--

For the purposes of evaluating and modeling the present and future air quality in the Denver metropolitan area, a number of emissions inventories of present and estimated future emissions of various air pollutants including carbon monoxide, particulates, oxides of nitrogen and hydrocarbons have been developed. These inventories were compiled primarily by the staff members of the Air Pollution Control Division of the Colorado Department of Health and by the Colorado Division of Highways. A discussion of current emissions is presented next. Future emissions which were utilized to predict 1985 and 2000 air quality levels will be discussed in the Probable Impact chapter.

The air pollutant emissions that constitute the main problem in the Denver Metropolitan Area at present are carbon monoxide, particulates, reactive hydrocarbons (which react to form ozone) and also the oxides of nitrogen. Automobile traffic accounts for a major fraction of the pollutants emitted. All traffic accounts for roughly 80 percent of the hydrocarbon emissions, 30 to 40 percent of the nitrogen oxide emissions, and about 90 percent of the carbon monoxide emissions. It is thought that while automobiles and other vehicles do not directly contribute a high proportion of the particulate emissions in the Denver Metropolitan Area, street sanding operations, which are related to the operation of these vehicles, contribute anywhere from 45 to 60 percent of the total particulate emissions. Next to automobiles and other traffic point sources are the most significant contributors to total emissions. Large point emissions

Table II-B. MAXIMUM POLLUTION CONCENTRATIONS MEASURED DURING 1974 AND 1975 IN DENVER

	One-hour CO[a]						Eight-hour CO[b]						One-hour O_3[c]					
	Days with violations, %		2nd max PPM		Max PPM		Days with violations, %		2nd max PPM		Max PPM		Days with violations, %		2nd max PPM		Max PPM	
Sample	1974	1975	1974	1975	1974	1975	1974	1975	1974	1975	1974	1975	1974	1975	1974	1975	1974	1975
CAMP	2	2	61	46.1	70	47.2	29	21	28.9	22.3	30.3	22.6	9	5	.180	.115	.185	.132
Nat. Jewish	2	2	49	43.1	59	51.4	17	19	19.1	23.1	19.7	24.0	9	4	.140	.108	.155	.110
Arvada	0		28	23.5	32	26.9	8	3	15.2	14.0	17.0	16.0	21	22	.170	.178	.220	.197
CARIH	0		26	27.3	27	27.9	10	8	14.8	21.9	18.6	23.3	14	17	.140	.135	.155	.139
Overland	0		25	22.5	30	28.8	4	2	11.7	12.0	14.6	15.0	15	13	.165	.135	.165	.139
Welby	0		22	27.5	24	30.8	6	4	13.5	16.6	16.3	19.0	36	18	.250	.177	.375	.182

[a] One-hour CO standard = 35 PPM

[b] Eight-hour CO standard = 9 PPM

[c] One-hour O_3 standard = .08 PPM

Source: JRPP Air Quality Assessment Statement, Colorado Division of Highways,
1 November 1976.

alone account for as much as 50 percent of the total emissions of the oxides of nitrogen. Table II-C gives the Denver emissions inventory estimated for 1974.

Public Concern--

While the air pollution standards were developed out of concern for public health and physical welfare, it is also important to consider the public's feelings towards air pollution in allocating and directing resources to help solve the problem. Information which was gathered by six surveys conducted between 1969 and 1972 about public attitudes towards Denver's air pollution problem is briefly presented here. These six surveys were different in intent but do have common elements which can be treated collectively. A more detailed review and summarization of these public survey results is contained in Reference 997. Information from these same six surveys on the public attitude in Denver towards air pollution control measures is presented briefly in the section on Mitigation Measures.

It appears to the public that air pollution is a serious problem. In three surveys, over 90 percent of the respondents indicated that air pollution was serious in some degree with 40 to 50 percent indicating it was "very serious" or extremely serious." This latter range is comparable to other findings from Buffalo, New York where air pollution was considered a serious problem by 40 to 60 percent of the total sample. Two of the Denver surveys ranked air pollution as the number one problem from a list of neighborhood or environmental problems. However, in the Buffalo survey air pollution was ranked behind juvenile delinquency and unemployment, and about the same as alcoholism. In another Denver survey air pollution was not ranked first among a group of problems but, ranked third behind help for schools and help for children on drugs.

Two of the Denver public surveys indicated concern about air pollution in terms of reducing existing pollutant levels. In one survey, 91 percent of the respondents considered reducing pollutant levels important in metropolitan Denver. In another survey 81 percent of the respondents indicated that either a "moderate" (27 percent) or "great" (54 percent) increase was needed in efforts to control air pollution.

Information about the perceived causes of air pollution is also available from the Denver surveys. In one survey 56 percent indicated their belief that "motor vehicles" were the worst cause of air pollution while in another survey 72 percent thought "automobiles" were the major source. These results indicate that the Denver public perceives the causes of the problem with some accuracy as motor vehicles are the major source of both carbon monoxide and hydrocarbons (which lead to ozone formation) in Denver and significant contributors to other pollutants.

Table II-C 1974 DENVER EMISSIONS INVENTORY

Source	Emissions, tons	Contributions, %
Carbon monoxide[a]	(per day)	
Automotive	2,925.0	94.5
Space heat	2.9	0.1
Point sources	167.6	5.4
Total	3,095.5	100.0
Hydrocarbons[b]	(per day)	
Automotive	199.18	83.9
Space heat	0.48	0.2
Oil paint	2.08	0.9
Gas stations	11.67	4.9
Cleaners	4.94	2.1
Incinerators	0.11	0.0
Point sources	13.14	5.5
Airports	5.92	2.5
Total	237.52	100.0
Particulate	(per year)	
Space heat	511	1.4
Automotive	4,213	11.9
Airports	63	0.0
Construction	8,730	24.7
Streed sanding	15,857	44.9
Point sources	5,981	16.7
Total	35,355	99.6
NO_2	(per year)	
Space heat	5,348	7.4
Small points	87	0.0
Automotive	31,646	43.7
Airports	1,552	2.1
Point sources	33,773	46.6
Total	72,406	99.8

[a] Based on winter emissions distributions.

[b] Based on summer emissions distributions.

Geology

The Denver area is divided into two distinct bedrock regions, both of which dip to the east. The slightly dipping strata of the plains is separated by a north-northwest, south-southwest trending zone of sharp, almost vertical folds from the steeply dipping strata of the Front Range. The locations of unique and significant geological structures and formations are shown on Map E and described in Appendix Table A-2.

The most important potential geologic problem in the Denver area is the shrink-swell characteristics of bartonitic clays found in the Denver-Arapahoe and other formations underlying most of the clay-derived soils in the area. Shrink-swell potential, which can place severe restrictions on urban development because of slippage and differential settling risks, is greatest in the foothills west of Denver where special site is needed. This potential is moderate-to-low elsewhere in the region. Other, less widespread geologic hazards include landslides in the western foothills having slopes greater than 25 percent and soils supported by clay substrata; subsidence and slope instability in mining areas found scattered on the north, west, and south peripheries of the metropolitan area; and faults (see Map C) representing a very low potential for seismic activity in the region.

Soils

Soils in the study area have been surveyed by the U.S. Soil Conservation Service (SCS) in recent years. Final survey reports have been published for Adams and Arapahoe Counties (Reference 701 and 702), while the results of the other county soil surveys for the study area have yet to be published.

Because considerations of the agricultural capabilities of the regional soils will be discussed at length under "Land Use Management Considerations, Agricultural Lands" this discussion will address only general soil-related problems. The major problem of most soils in the region is shrink-swell characteristics as discussed above and in Appendix A. The other significant regional soils problem is aeolian, i.e., wind erosion. Where dryland farming is practical, wind erosion causes losses of valuable topsoil during severe windstorm episodes. This problem is especially critical in the dryland farming areas of Adams and Arapahoe Counties.

Hydrology

The principal hydrologic feature is the South Platte River and its tributaries. The South Platte River and the tributaries of Bear Creek, Clear Creek, Boulder Creek and Coal Creek have their headwaters in the mountains to the west (see Map E). They are snowmelt streams whose annual variation of flow are directly related to the snow pack accumulated during the previous winter. Approximately 75 percent of the annual flow occurs during the spring and early part of the summer, peaking in May or June. The remaining 25 percent of the flow occurs during the fall and winter months, with the low flow in January or February. The other major tributaries including Cherry Creek, Sand Creek, Big Dry Creek and Plum Creek rise on the plains east of the mountains. Flow of these streams comes principally from precipitation. All streams in the study area respond vigorously to frontal and thunderstorm rainfall events.

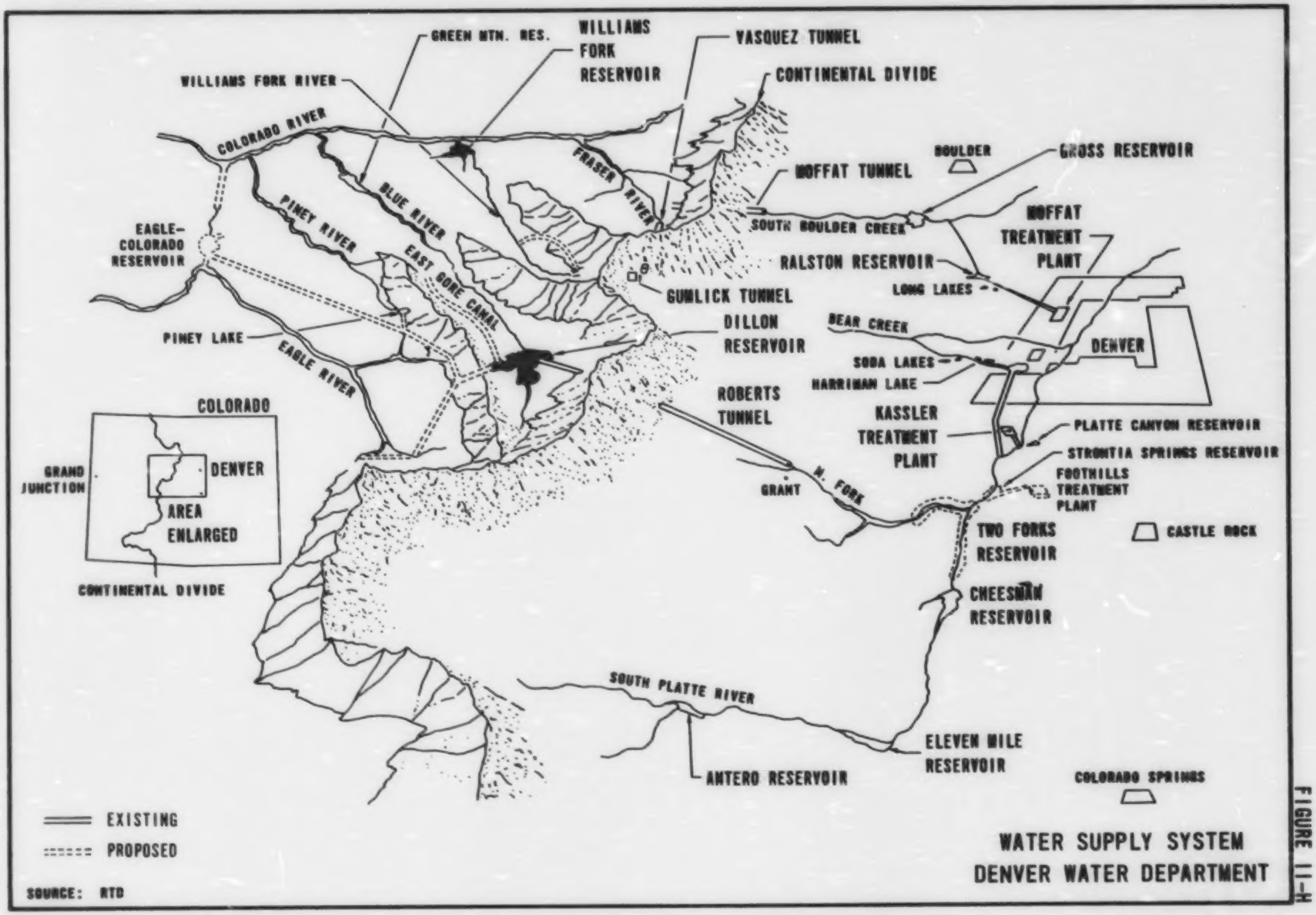
The natural flow of the South Platte River is insufficient to meet the total demand of municipal, industrial, and agricultural users, which has lead to an elaborate regulation and distribution system consisting of diversions for irrigation, transmoutain diversions to augment basin supplies and numerous reservoirs for irrigation and flood control (see Figure II-H). This system of water use, reuse and subsequent use radically alters the natural flow characteristics of many streams. Flows in Cherry Creek below Cherry Creek dam are sometimes comprised entirely of urban runoff. At times, the flow in Clear Creek below Golden is primarily from sewage treatment plant effluent and at other times it is dry due to irrgation diversions. Sand Creek is frequently an intermittent stream with periods of no flow. Normal flows in Big Dry Creek are primarily irrigation and irrigation return flows in addition to urban runoff.

Past urbanization has severely constricted some of the drainage ways to the point where structural measures are necessary to safely pass a 100 year flood without substantial property damage. Several structural flood control projects have been undertaken in the area to at least the master planning design stage. They include Chatfield Dam, Cherry Creek Dam, and Bear Creek Lake Dam (under construction), and channel improvements for Sanderson Gulch which is designed for the 10 year flood event. Regulations are in effect in the counties of Jefferson and Boulder, and the cities of Arvada, Lakewood, Boulder, and Thornton to limit the peak rate of runoff from urbanizing lands to the historic peak rate. The basin or regionwide effect of requiring individual developments to provide detention to meet historic peak runoff requirements is yet to be determined for the study area. The aggregate effect may be higher peak rates of runoff for downstream reaches because detained hydrographs from individual subbasins are long and flat and are more likely to become additive. Present major drainage planning is based on future basin development and considers that detention requirements will not be effective (see Map G).

Water Supply

The largest municipal water supplier is the Denver Water Department which provides the City and County of Denver plus a number of suburban cities, special districts and other agencies with approximately

FIGURE II-H


GREEN MTN. RES.
WILLIAMS FORK RESERVOIR
VASQUEZ TUNNEL
WILLIAMS FORK RIVER
CONTINENTAL DIVIDE
COLORADO RIVER
FRASER RIVER
BOULDER
GROSS RESERVOIR
MOFFAT TUNNEL
MOFFAT TREATMENT PLANT
BLUE RIVER
PINEY RIVER
EAGLE-COLORADO RESERVOIR
SOUTH BOULDER CREEK
RALSTON RESERVOIR
EAST GORE CANAL
LONG LAKES
GUMLICK TUNNEL
PINEY LAKE
DILLON RESERVOIR
BEAR CREEK
DENVER
EAGLE RIVER
SODA LAKES
HARRIMAN LAKE
ROBERTS TUNNEL
COLORADO
KASSLER TREATMENT PLANT
PLATTE CANYON RESERVOIR
GRAND JUNCTION
DENVER
STRONTIA SPRINGS RESERVOIR
AREA ENLARGED
GRANT
N. FORK
FOOTHILLS TREATMENT PLANT
CONTINENTAL DIVIDE
TWO FORKS RESERVOIR
CASTLE ROCK
CHEESMAN RESERVOIR
SOUTH PLATTE RIVER
ELEVEN MILE RESERVOIR
ANTERO RESERVOIR
COLORADO SPRINGS
EXISTING
PROPOSED

SOURCE: RTD

WATER SUPPLY SYSTEM
DENVER WATER DEPARTMENT

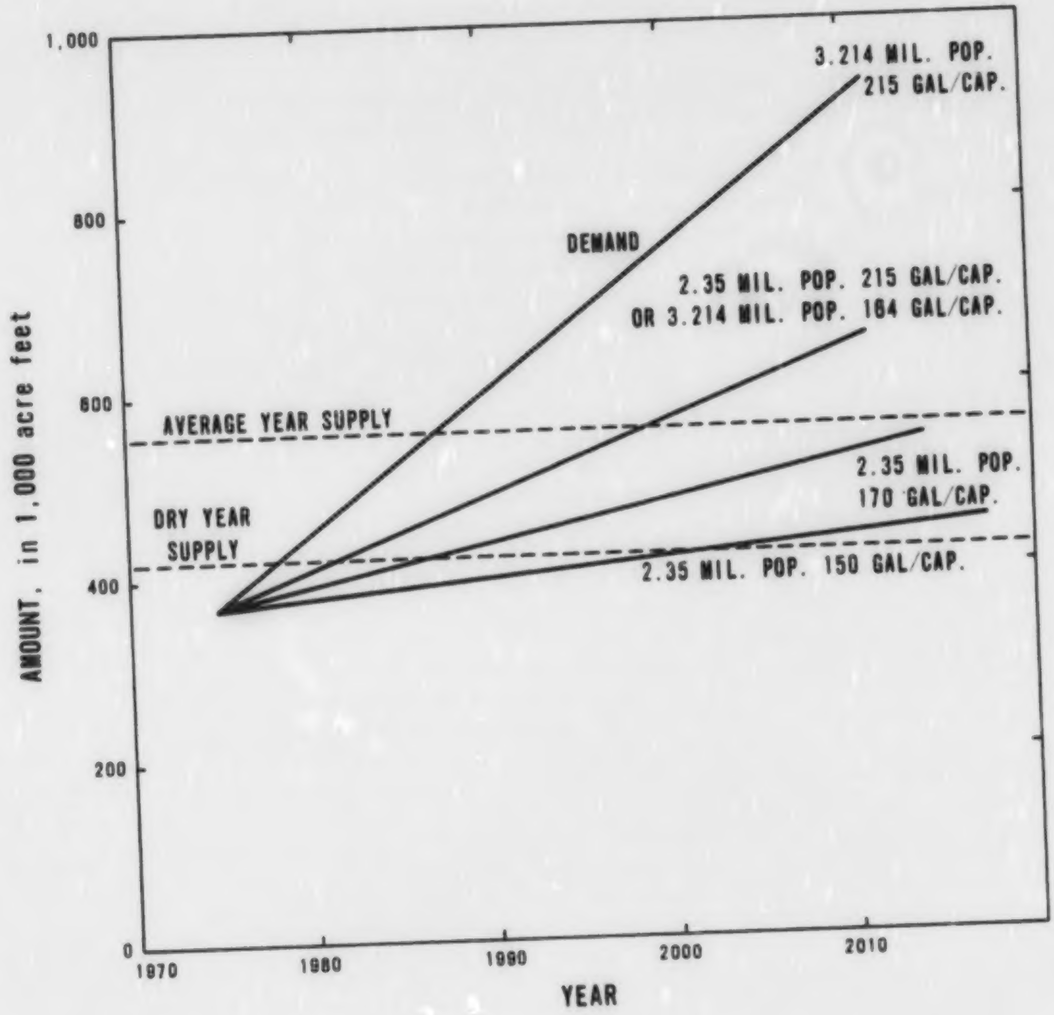
two-thirds of the municipal raw water used in the region. The next largest independent system is Aurora's which supplies over six percent of the region's annual raw water demand. Thirty-three percent of the raw water utilized for municipal purposes in the region is transmountain water imported from the headwaters of the Colorado River west of the Continental Divide by the cities of Denver, Aurora, Englewood, and Boulder. Projections of future water supplies and demands by the Denver Water Board indicate that demand for will exceed dry year supplies before 1980 and average year supplies by 1988. Figure II-I graphically shows dry year and average year water supplies relative to two rates of demand based on two population projections and the effect of water conservation. Under existing use conditions, planning proposals, and water rights laws, new water supplies would likely be imported rather than developed in the Denver basin where existing supplies are near or at maximum utilization. The year 2000 projection of 3.214 million was the one used by the Denver Water Board. The year 2000 projection of 2.35 million is the one developed by DRCOG and is used for water quality planning.

There are two groundwater systems in the Denver area. The first (see Map C) is the shallow groundwater system of aquifers underwater table conditions found in the floodplains and terraces of the South Platte River basin, in the dune sand deposits that occur in the vicinity of the Rocky Mountain Arsenal, and in the alluvial fan remnants that occur adjacent to the front range mountains. Recharge to these aquifers occurs in areas where deposits are exposed to the land surface. Further onto the plains area, streams receive groundwater discharges from shallow groundwater aquifers which accounts for much of the flow in the South Platte basin during the latter part of the summer. These shallow groundwater aquifers are also sources for domestic water supply. The second system is the deep groundwater system consisting of Dawson, Denver, Arapahoe Formations and the Laramie-Fox Hills sands containing water under pressure at depths ranging from 500 to 3,000 ft. beneath the Denver area. Recharge generally occurs throughout the sourthwestern quarters of the study area and discharge in the northwestern quarter. These aquifers are exposed at the surface in an oval-shaped structure where streams cross the exposed sandstones. Recharge also occurs by vertical percolation of groundwater through overlying beds of shale in the Denver and Castle Rock areas. North of Dawson the deep aquifers discharge groundwater vertically to the land surface.

Water Quality

The following discussions of current water quality in the Denver region are based in large part on information developed

FIGURE II-1



NOTE: POPULATION FIGURES ARE
FOR THE YEAR 2000.

PRIMARY AREA WATER SUPPLY AND DEMAND
(DATE FROM 1975 METRO WATER STUDY)

by DRCOG and its consultants to support the preparation of the Denver Clean Water Program (CWP). This program is frequently or commonly termed the 208 Plan because it is required by Section 208 of the Water Pollution Control Act Amendments of 1972.

Detailed technical information that supports the discussion presented here can be found in Appendix A and on Map E.

A number of parameters (physical, chemical, and biological characteristics) are used to indicate water quality. These characteristics are important because they either directly affect people and wildlife or indirectly interact to cause effects. For example, certain amounts of dissolved oxygen (DO) in the water are necessary to support fish life and other desirable organisms. Water temperature (T) affects the amount of dissolved oxygen water can contain. Biological oxygen demand (BOD) refers to the amount of organic material which is available as food for various organisms. When a large amount of food is available, the number of organisms increase and the amount of oxygen in the water is reduced. The term BOD_5 is commonly used to indicate the BOD over a five day period. Total dissolved solids (TDS) are in the form of salts. High TDS in water for agriculture limits crop productivity and can cause salts to build up in soils and permanently degrade agricultural soils. High TDS makes water disagreeable to taste and can cause effects such as diarrhea. It also limits the use of water by industry in manufacturing processes. Fecal coliforms and streptocci (colistrep) are bacteria naturally occurring in the intestines of humans and warm-blooded animals. The presence of these bacteria are used as indicators of fecal contamination of water, and thus the possible presence of disease causing bacteria. Ammonia (NH_3) is toxic to fish. Nitrogen and phosphorous compounds (NO_3, PO_4) supply nutrients to small water-borne plantlike organisms. Algal blooms may occur and cause unpleasant odors and unsightliness. Also, when these organisms die and decay, they represent a BOD.

Desired Water Quality--

During the 208 Planning Study, various water uses were considered and evaluated for the study area. Four broad areas of desirable uses were identified: agriculture (irrigation and livestock watering), recreation (primary and secondary contact) maintenance of aquatic life (cold and warm water fisheries and stream or lake aesthetics) and domestic raw water supply.

Stream classifications and the requisite stream quality parameter values for these uses are indicated in Table II-D.

Table II-D. STREAM CLASSIFICATIONS AND ALLOWABLE LIMITS FOR SPECIFIC WATER USES

Stream classification	Uses	Water quality parameters/limits									
		Temperature, °C	Dissolved oxygen, mg/1	BOD_5, mg/1	Total dissolved solids, mg/1	Fecal coliforms, MPN/100 ml	Fecal streptococci, MPN/100 ml	NH_3-N, mg/1	NO_3-N, mg/1	Total N, mg/1	PO_4-P, mg/1
B_2	Aesthetics (stream), wildlife and livestock watering, urban irrigation, secondary contact recreation, warm water fishery	8 to 30	5	-	1,000 to 3,000	200 to 1,000	20	0.3 to 4	10	10	0.05
B_1	Same as above (B_1) except cold water fishery	5 to 15	6	-	1,000 to 3,000	200 to 1,000	20	0.6 to 5	10	10	0.05
A_2	Aesthetics (stream or lake), wildlife and livestock watering, urban irrigation, primary contact recreation, domestic potable water (raw supply), warm water fishery, plus all B_2 uses	8 to 30	5	-	500	200	20	0.3 to 0.5	10	10	0.025 to 0.1
A_1	Same as above (A_2) except as cold water fishery, plus all B_1 uses	5 to 15	6	-	500	200	20	0.5 to 0.8	10	10	0.025 to 0.1

Source: References 209 and 228

The values shown are those used in the 208 Study and will be utilized in this report both as being consistent with the available data base and as representing the latest available information. Table II-E indicates the classification by reach of the streams within the study area.

Table II-F presents the historical and present uses, precent State stream classification; and the latest suggested use potential and classification of the major streams in the study area. It should be recognized that the use potential represents goals for the study area consistent with the national goals of "fishable and swimmable waters" by 1983 and "zero" discharge of pollutants by 1985 as stated in the Federal Water Pollution Control Act Amendments of 1972.

Existing Water Quality--

The following subsections present the existing water quality in the study area by basin. Table II-G is a list of the wastewater treatment facilities that were investigated for their impact upon stream water quality. Discussions are based on stream data obtained during calendar year 1972.

Data for 1972 was used largely because this was the year picked by DRCOG for 208 planning as most representative of flow conditions for the last several years and for which water quality data were available.

The data used to characterize water quality in 1972 is summarized in Table II-H. This data is compared with the recommended levels shown in Table II-D for stream classifications shown in Table II-E, to evaluate water quality in 1972.

Basin Water Quality Trends/South Platte-- The following discussions are based primarily on average levels for various water quality parameters. Effects of runoff events will be discussed after each water quality parameter is examined.

Water temperature, in addition to following normal seasonal trends, generally increases as flow proceeds through the urbanized area of the basin. Temperatures are within limits for the water uses designated for the various streams or portions of streams except for Bear Creek above Morrison, and the South Platte above Littleton. Temperature limits are sometimes exceeded during late summer.

Table II-E. CLASSIFICATION BY STREAM AND REACH

Stream	Use class	Reach
South Platte	B_1	Source to Exposition Avenue
South Platte	B_2	Exposition Avenue to Nebraska
Sloans Lake	A_2	Inlet to outlet
Bear Creek	B_1	Source to Morrison
Bear Creek	B_2	Morrison to South Platte
Cherry Creek Reservoir	A_2*	Inlet to outlet
Cherry Creek	A_2*	Source to reservoir
Cherry Creek	B_2	Reservoir to South Platte
Clear Creek	B_1	Source to Farmers Highline Canal
Clear Creek	B_2	Farmers Highline Canal to South Platte
Coal Creek	B_1	Source to Highway 93
Coal Creek	B_2	Highway 93 to mouth
South Boulder Creek	B_1	Source to Highway 93
South Boulder Creek	B_2	Highway 93 to mouth
Boulder Creek	B_1	Source to Highway 119
Boulder Creek	B_2	Highway 119 to mouth
Sand Creek	B_2*	Source to South Platte
Big Dry Creek	B_2*	Source to South Platte

*Assumed for 208 study; not State of Colorado classification.
Source: Reference 228

Table II-F. WATER QUALITY ATTAINABILITY/USE POTENTIAL

208 Basin	Historical and present use	Present state classification	Use potential	Use classification
Upper South Platte	Natural trout stream formerly Cold-water put-and-take fishery at present to Chatfield Reservoir Swimming, rafting during high flows	B_1 Cold-water fishery	Natural cold-water fishery with suitable substrate and flow conditions Swimming, rafting	Secondary-contact recreation March - August Cold-water fishery
South Metro	Natural trout stream formerly	B_1 Cold-water fishery (to Exposition Avenue)	Rafting, boating Cold-water fishery, put-and-take	Secondary-contact recreation March - August Cold-water fishery
Lower South Platte through Lakewood Basin	Only rough fish in flowing waters or pooled areas Some waterfowl use and some boating	B_2 Warm-water fishery (from Exposition Avenue)	Boating Warm-water fishery	Secondary-contact recreation March - August Warm-water fishery below Exposition Avenue March - June Agricultural/industrial use remaining months
Lower South Platte through Clear Creek Basin	Only rough fish in flowing waters/or pooled areas Some waterfowl	B_2 Warm-water fishery (from Exposition Avenue)	Boating Warm-water fishery	Secondary-contact recreation March - August Warm-water fishery below Exposition Avenue March - June Agricultural/industrial use remaining months
Lower South Platte below 104th Avenue	Only rough fish in flowing waters or pooled areas Boating during high flows	B_2 Warm-water fishery	Warm-water fishery with increased flows and improved quality Boating, rafting	Secondary-contact recreation March - August Warm-water fishery March - June Agricultural/industrial use remaining months
Cherry Creek above reservoir	Rough fish Rafting in Highline Canal during high flows	Unclassified (A_2 reservoir)	Warm-water fishery	Secondary-contact recreation March - August

Table II-F. (continued) WATER QUALITY ATTAINABILITY/USE POTENTIAL

208 Basin	Historical and present use	Present state classification	Use potential	Use classification
Cherry Creek below reservoir	Rough fish and some warm-water fish when flows consistent Boating in downstream areas	Unclassified	Potential for secondary-contact recreation in downstream areas Warm-water fishery in downstream areas, upstream with flow releases Boating	Secondary-contact recreation in downstream segments March - August Warm-water fishery March - June upstream, entire year downstream Agricultural/industrial use remaining months
Sand Creek	Rough fish in pooled areas most of the year No recreation	Unclassified	Recreational potential during high flows No fishery potential, only rough fish	Secondary-contact recreation March - August Agricultural/industrial use remaining months
Bear Creek through Morrison	Natural trout fishery to Morrison formerly Put-and-take fishery at present	B_1 Cold-water fishery (to Morrison)	No recreation potential in upstream area Natural cold-water fishery potential	Cold-water fishery
Bear Creek below Morrison	Some put-and-take fishery at present Rafting, boating downstream from Morrison	B_2 Warm-water fishery (from Morrison)	Recreation potential for rafting, boating Potential for cold-water fishery with releases from Mr. Carbon Reservoir	Secondary-contact recreation March - August Cold-water fishery March - June Agricultural/industrial use remaining months
Clear Creek to Golden	Natural cold-water fishery formerly Natural cold-water fishery to Idaho Springs Fish populations precluded from Idaho Springs to Golden from low pH values, heavy metals	B_1 Cold-water fishery (to Highline Canal)	Natural cold-water fishery to Golden	Cold-water fishery
Clear Creek below Golden	Some trout and downstream some warm-water fish species Boating, rafting downstream of Golden	B_2 Warm-water fisheries (Highline Canal downstream)	Rafting, boating Warm-water fishery downstream of Golden	Secondary-contact recreation March - August Warm-water fishery March - June Agricultural/industrial use remaining months

Table II-F. (continued) WATER QUALITY ATTAINABILITY/USE POTENTIAL

208 Basin	Historical and present use	Present state classification	Use potential	Use classification
Big Dry Creek upstream of Standley Reservoir	Put-and-take cold-water fishery upstream of Standley Reservoir	Unclassified	Cold-water fishery	Cold-water fishery
Big Dry Creek below Standley	Rough fish and warm-water fishery	Unclassified	Warm-water fishery with sufficient flows	Warm-water fishery March - June Agricultural/industrial use remaining months
Coal Creek to intersection with Route 93	Natural cold-water fishery upstream formerly Put-and-take at present	B_1 Cold-water fishery	Cold-water fishery	Cold-water fishery March - June Agricultural/industrial use remaining months
Coal Creek Route 91 to South Platte	Rough fish and warm-water fishery	B_2 Warm-water fishery	Warm-water fishery	Warm-water fishery March - June Agricultural/industrial use remaining months
Boulder Creek source to Route 119	Natural cold-water fishery	A_1 Domestic use, primary/secondary-contact recreation, fisheries	Domestic use, recreation Cold-water fishery	Domestic use, recreation Cold-water fishery
Boulder Creek Route 119 to 93	Cold-water put-and-take fishery Rafting, swimming	B_1 Cold-water fishery	Primary-contact recreation Cold-water fishery with reservoir releases	Primary-contact recreation Cold-water fishery
Boulder Creek Route 93 to St. Vrain Creek	Cold-water put-and-take fishery and warm-water fishery	B_2 Warm-water fishery	Cold-water fishery with flows, otherwise warm-water fishery	Cold-water fishery March - June Warm-water fishery June - February Agricultural/industrial use remaining months

Note: Historical and present uses were obtained through existing literature sources and from interviews RPA conducted with state and local experts in fisheries and water quality management and with DRCOG representatives during the week of December 6-10 in the Denver area. State classifications are those made effective June 19, 1974. Use potential is a concensus of opinion of the experts interviewed for this analysis and RPA's professional judgment as to the highest and best uses for these stream segments; use potential responds to the Colorado State Water Quality Control Commission's desire to assign a stream classification for the highest and best use to which a stream segment could be put on the basis of past and present uses and/or natural conditions. Use potential does not consider the technological capability, cost, or socio-economic impact of implementing such a classification. The use classification is presented as RPA's recommendation for stream classification to meet permits for Denver area streams. Those recommendations would be enforced by the Water Quality Commission as exception to the permanent stream segment classifications.

Source: Reference 259

Table II-G. WASTEWATER TREATMENT FACILITIES INVESTIGATED FOR THEIR IMPACT ON EXISTING WATER QUALITY

Plant	Type	Capacity, mgd		Receiving Stream
		Primary	Secondary	
Morrison	Activated sludge rotot aeration	0.07	0.07	Bear Creek
Glendale	Activated sludge	1.0	1.0	Cherry Creek
Aurora	Activated sludge	1.5	1.5	Sand Creek
Fitzsimons	Trickling filter	0.9	0.9	Tollgate Creek
Coors	Activated sludge	4.0	9.0	Clear Creek
Wheatridge	Trickling filter	2.5	2.5	Clear Creek
Clear Creek Valley	Activated sludge	2.1	2.1	Clear Creek
Arvada	Trickling filter	0.7	0.7	Clear Creek
Crestview	Trickling filter	1.0	1.0	Clear Creek
Littleton	Trickling filter activated sludge	7.6	7.6/1.5	South Platte
Englewood	Trickling filter	12.0	12.0	South Platte
South Lakewood	Activated sludge	1.3	1.3	South Platte
Metro Denver #1	Activated sludge	28.0	98.0	South Platte
South Adams County	Trickling filter	2.5	2.5	South Platte
Broomfield	Trickling filter	1.6	1.6	Big Dry Creek
Westminster	Activated sludge	1.0	1.0	Big Dry Creek
Erie	Lagoon	2.57 acres		Coal Creek
Lafayette	Trickling filter	0.3	0.3	Coal Creek
Louisville	Activated sludge aerated lagoon	0.7	0.7	Coal Creek
Boulder White Rocks	Trickling filter	15.6	15.6	Boulder Creek

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Table II-H. EXISTING WATER QUALITY (1972)

Location	State-assigned classification	Temperature, °C		Dissolved oxygen, mg/l		Total dissolved solids, mg/l		BOD,[a] mg/l		Ammonia, mg/l		Nitrate, mg/l		Phosphate, mg/l		Fecal coliforms, MPN/100 ml		Fecal streptococci, MPN/100 ml	
		Avg	Peak	Avg	Peak	Avg	Peak	Avg	Peak	Avg	Peak	Avg	Peak	Avg	Peak	Avg	Peak	Avg	Peak
Winter																			
Bear Creek at Morrison	B_1	6	12	12	15	90	95	3	4	0.13	-	0.31	-	0.23	-	200	-	300	-
Beark Creek at mouth	B_2	10	17	11	12	200	3,800	4	42	0.2	1.8	1.0	6	0.3	2	300	15,000	700	154,000
Cherry Creek at Franktown	A_2	2	4	13	14	250	-	2	-	0.01	0.05	0.11	0.15	0.01	-	-	-	-	-
Cherry Creek at mouth	B_2	8	18	10	12	480	6,800	3	81	1.0	3.5	3.0	5	4	7	650	26,000	1,800	264,000
Sand Creek at mouth	B_2	9	15	12	-	900	4,000	9	43	5	7	3	4	3.5	4.5	2,500	19,000	4,000	123,000
Clear Creek at Golden	B_1	4	10	13	15	200	500	2	5	0.23	-	0.4	-	0.2	-	204	600	300	400
Clear Creek at mouth	B_2	8	20	11	12	400	4,000	18	50	4	11	2.5	4	3.2	5	800	25,000	300	200,000
South Platte at Blakeland	B_1	7	12	9.5	10	250	-	5	-	0.01	-	0.03	-	0.05	-	30	35	40	45
South Platte at 38th Ave.	B_2	8	15	10.5	12	500	4,500	14	17	3	3.8	1.5	1.8	2	4.5	600	17,000	20,000	130,000
South Platte at Henderson	B_2	8	16	9.5	11	700	4,000	30	33	10	13	1.8	5	5	6.5	1,000	16,000	2,500	125,000
Spring																			
Bear Creek at Morrison	B_1	10	14	10	11	85	100	3	4	0.13	-	0.31	-	0.23	-	400	1,500	300	1,000
Bear Creek at mouth	B_2	20	25	9.5	11	220	3,000	3	32	0.2	0.7	1.5	4.5	0.3	2.3	300	15,000	700	121,000
Cherry Creek at Franktown	A_2	10	16	10	11	75	150	1.3	2	0.02	-	0.16	0.18	0.03	0.06	-	-	-	-
Cherry Creek at mouth	B_2	20	25	8.5	9.8	650	4,750	3	61	0.6	2.7	2	4.5	2.5	5.8	800	6,000	1,000	22,000
Sand Creek at mouth	B_2	20	25	10	11	1,500	3,600	10	35	5	6	3	5.2	2.5	5	2,500	14,500	4,000	84,000
Clear Creek at Golden	B_1	10	13	8	8	275	500	2.5	5	0.23	-	0.4	-	0.2	-	400	600	200	400
Clear Creek at mouth	B_2	20	25	8.5	11	400	600	8	15	1.5	7.3	2	2.8	1.7	3.4	800	10,000	300	90,000
South Platte at Blakeland	B_1	15	18	7	9	250	-	5	-	0.01	-	0.03	-	0.05	-	15	40	32	40
South Platte at 38th Ave.	B_2	17	24	8.5	10	600	1,000	10	17	1.5	3.5	1.5	2.8	1	3.5	600	20,500	20,000	100,000
South Platte at Henderson	B_2	18	23	8.3	9	700	1,000	16	20	8	15	1.8	4	3	6.5	1,000	5,000	2,500	65,000

Table II-H. (Continued) EXISTING WATER QUALITY
(1977)

Location	State assigned classification	Temperature, °C		Dissolved oxygen, mg/l		Total dissolved solids, mg/l		BOD,[a] mg/l		Ammonia, mg/l		Nitrate, mg/l		Phosphate, mg/l		Fecal coliforms, MPN/100 ml		Fecal streptococci, MPN/100 ml	
		Avg	Peak	Avg	Peak	Avg	Peak	Avg	Peak	Avg	Peak	Avg	Peak	Avg	Peak	Avg	Peak	Avg	Peak
Summer/Fall																			
Bear Creek at Morrison	B_1	14	20	10	12	85	95	2.5	3	0.13	-	0.31	-	0.23	-	200	-	300	-
Bear Creek at mouth	B_2	21	28	9	10.2	250	3,600	2	41	0.15	1.8	1.0	4.3	0.3	1.7	300	18,000	700	140,000
Cherry Creek at Franktown	A_2	15	20	10	12	230	250	2.7	3	0.07	0.10	0.18	0.20	0.04	0.05	-	-	-	-
Cherry Creek at mouth	B_2	20	26	8.5	9.8	725	6,600	3	75	0.6	4.3	2.1	5.5	2.5	6.2	800	26,000	1,000	182,000
Sand Creek at mouth	B_2	20	26	9	10	1,200	3,300	6	35	3	6.5	3.5	4.5	3.5	8.5	2,500	12,500	4,000	56,000
Clear Creek at Golden	B_1	13	20	10	12	175	200	2	5	0.23	-	0.4	-	0.2	-	204	400	300	380
Clear Creek at mouth	B_2	22	28	9	10.5	400	600	8	13	1.2	2.5	2	2.3	1.4	1.5	800	10,000	300	90,000
South Platte at Blakeland	B_1	16	21	6.5	8	250	-	5	-	0.01	-	0.03	-	0.05	-	20	30	34	40
South Platte at 38th Ave.	B_2	20	26	8	9.1	650	4,600	10	16	1.8	3.6	1.8	4	1.5	4	600	16,000	20,000	130,000
South Platte at Henderson	B_2	20	27	8	9.2	700	2,000	10.2	16	7.5	12.5	2	3.5	4	6	1,000	10,000	2,500	75,000

[a] Biochemical oxygen demand.

Dissolved oxygen (DO), also follows expected seasonal trends with DO levels decreasing from winter levels during the course of the year until fall when water temperatures begin to decrease, and DO levels begin to rise. Dissolved oxygen levels decrease as water flows through the Denver area. Dissolved oxygen levels consistently meet recommended limits for the various water uses.

Total Dissolved Solids (TDS) show weak seasonal trends, but seem most influenced by flow through the urban area. TDS levels for tributaries to the South Platte generally increase by a factor of two as streams progress through the urban area. With the exception of Sand Creek, levels for TDS are at or below limits recommended for specific water uses. The high RDS levels in Sand Creek are due in large measure to the nature of the creek bed, and the gravel mining which occurs on upstream portions of the stream.

Five day Biological Oxygen Demand (BOD_5) levels generally are fairly constant throughout the year in the upstream portions of basin streams. The same is also true at the mouth of Cherry Creek. BOD_5 levels where Bear and Clear Creeks enter the Platte and on the Platte below Littleton decrease from winter highs to lowest levels in the summer and fall. Only Sand Creek at the mouth showed peak levels in the spring instead of winter. These trends appear to indicate a greater influence from point sources during wintertime low natural stream flows. The highest BOD_5 levels in the South Platte occur at Henderson, and the highest levels in tributaries occur at the mouths of the Clear and Sand Creeks.

The downstream portions of Clear, Sand, and Cherry Creeks as well as the South Platte below Littleton have ammonia (NH_3) concentrations (in conjunction with pH and temperature) which are on the average at potentially toxic levels throughout the year. The highest levels, 10 mg/1, occur in the South Platte at Henderson during the winter. Highest ammonia levels generally occur in winter for the streams mentioned. Ammonia levels in the headwaters are at acceptable levels.

Nitrate levels throughout the South Platte basin are within acceptable levels. Table II-H shows that the highest levels occur in Sand Creek, Cherry Creek, and Clear Creek where these creeks flow into the South Platte. These levels vary between 2.0-3.5 mg/1, which is singificantly below the recommended limit of 10 mg/1 for Nitrate. However, recommended levels for total nitrogen are exceeded in the South Platte at Henderson.

Levels of phosphate exceed recommended levels throughout the basin during the year except for wintertime levels in Cherry Creek above Cherry Creek Reservoir and the South Platte above Littleton which is at the limit. Phosphate levels increase downstream from upstream. The upper portion of Cherry Creek above the reservoir is the only headwater showing a variation in levels through a year. Bear Creek at the mouth had constant levels of phosphate, however, a seasonal trend is very pronounced for the remainder of the tributaries where they flow into the South Platte as well as for the South Platte itself. This trend begins with high levels during the winter, with generally lower levels throughout the remainder of the year until fall when levels begin to climb to winter highs. Phosphate levels are highest in the South Platte at Henderson where levels of 5.0 mg/l occur. The recommended level is 0.05 mg/l. The next highest levels occur in Cherry Creek at the mouth, 2.5-4.0 mg/l, Sand Creek at the mouth, 2.5-3 mg/l, and Clear Creek at the mouth, 1.4-3 mg/l.

Fecal coliform recommended limits are met year round only in the South Platte above Littleton. They are equalled during summer, fall, and winter in the headwaters of Bear and Clear Creeks, but are exceeded during spring. No data exists for Cherry Creek above Cherry Creek Reservoir, but a similar trend is expected. The higher levels in downstream portions of the basin are essentially constant throughout the year. The highest levels in the basin are found in Sand Creek at the mouth with 2500 MPN/100 ml.

Recommended limits for Fecal Streptocci (FS), 20 MPN/100ml, are exceeded throughout the South Platte basin throughout the year. The lowest levels, 32-40 MPN/100 ml, are found in the South Platte above Littleton. FS levels are essentially constant throughout the year except at the mouth of Cherry Creek where winter levels are substantially above levels for the remainder of the year. The highest levels in the South Platte basin occur in the South Platte at 38th Avenue in Denver, approximately one mile downstream of where Cherry Creek enters the South Platte. These levels are constant. The next highest levels 4,000 MPN/100 ml, are found in Sand Creek at the mouth. Very high levels are also found in the South Platte at Henderson, 2,500 MPN/100 ml, and at the mouth of Cherry Creek, 1,000-1,800 MPN/100ml.

The previous discussions were concerned with water quality during average conditions. Table II-G also indicates peak levels that occur during various seasons of the year. Data indicates that these peaks occur during runoff events such as snowmelt and/or rain in the region. A review of Table II-H

*MPN means Most Probable Number of organisms.

indicates that peak levels during runoff events at times exceed recommended levels which are in some measure met during average conditions for Total Dissolved Solids (TDS), and Ammonia (NH_3).

The following discussion will be limited to these two parameters. Temperature and Dissolved Oxygen levels by themselves are not generally a problem during runoff events, and peak levels of Nitrate are still within limits. Levels for Phosphate, Fecal coliform and Fecal streptococci generally exceed recommended levels during average conditions. The levels of these pollutants in the headwaters indicates a background level most probably caused by non-point sources further upstream.

Levels of TDS exceed recommended levels during runoff events throughout the year at the mouth of Bear, Cherry, and Sand Creeks and in the South Platte below Littleotn. Levels are exceeded at the mouth of Clear Creek during spring, summer, and fall. Few general statements can be made about trends because such factors as localized rain storms may have distorted the information given Table II-H. Two observations can be made however. The highest peak levels of TDS occurred in Cherry Creek. The reason for this is not known. This was true for every season of the year. Also, peak TDS levels are generally highest during the winter at the mouth of the tributaries, and downstream from Littleton in the South Platte. These winter peaks correspond to small peaks in flow which infers that the wintertime TDS peaks are associated with snowmelt runoff from streets treated with salts.

Virtually no data exists for Ammonia peak levels at the headwaters of the tributaries or for the South Platte above Littleton. The data for the lower reaches indicates recommended levels are exceeded during runoff events. No strong seasonal trends are apparent. The highest peaks in Ammonia concentrations occurred in the South Platte at Henderson with concentrations of from 12.5-15 mg/l.

Big Dry, Coal and Boulder Creek Basins--There are no significant existing data for these basins available for assessment of seasonal variations in water quality, nor are there sizeable amount of data for assessment of nonpoint or point-source water quality.

Water quality for Boulder Creek at its mouth (confluence with St. Vrain Creek) indicated an arthmetic mean of samples taken 7-12 September 1971 for BOD_5 of 2.8 mg/l, total dissolved solids of 955 mg/l, fecal coliform of 1,080 MPN/100 ml and fecal streptococcus of 14,500 MPN/100 ml. It has also been noted that below the Boulder/White Rocks treatment plant chlorine and ammonia residuals preclude the migration farther upstream of sensitive fish species; fecal coliform and fecal streptococcus counts increase from upstream levels; and dissolved oxygen falls to a range of 6 to 8 mg/l from upstream levels of 9 to 12 mg/l. The headwaters of Boulder Creek were noted to have high levels of dissolved oxygen and temperatures from November through March of 5°C. It has also been noted that Phosphate levels are apparently higher than suggested levels for stream aesthetics (0.06 mg/l).

Coal Creek, in the upper portion of its basin, has temperatures and dissolved oxygen levels sufficient to support a put-and-take trout fishery. The lower poriton's water quality was degraded in 1972 because of discharges from the Erie, Lafayette and Louisville municipal treatment plants and the extraction of coals, and show levels of fecal coliform and fecal streptococcus greater than 200 MPN/100 ml.

Water quality in the upper portion of Big Dry Creek Basin was unaffected in 1972 by point sources of pollution and has been suitable for use as a cold water fishery. It appears that levels of phosphate and total nitrogen are lower than suggested levels for stream aesthetics. In the lower portion, water quality is impacted by low releases from Standley Reservoir and point-source inflows from the Westminster and Broomfield municipal wastewater treatment plants. Coliform levels periodically exceed suggested levels for urban irrigation and secondary-contact recreation.

Sources of Water Quality Problems--

This discussion will address the causes of water quality problems identified in the two previous sections of this report. It is based upon material previously referenced and consists of data generated during DRCOG's 208 Water Quality Modeling and Planning activities. Table II-I presents a summary of pollutant amount in each basin by major categories, i.e., point sources and non-point sources. The following discussions are organized by basin as appropriate.

General--The two indicators of pathogenic organisms, fecal coliforms and streptococci, are a consistent problem throughout the South Platte basin. Table II-I clearly shows that the overwhelming majority of these organisms come from non-point sources. Point sources of fecal coliforms constitute less than one percent of the total number, and point sources of fecal streptococci constitute less than one-tenth of one percent.

Nitrates do not presently represent a water quality problem and will not be discussed further. The highest levels are found in the South Platte below 38th Avenue, 1.5-2.0 mg/l. These levels are significantly below the recommended level of 10.0 mg/l. However, Nitrates plus Ammonia levels at Henderson exceed total Nitrogen recommended levels of 10 mg/l in winter when total Nitrogen levels of 11.8 mg/l occur.

Table II-I. COMPARISON OF ESTIMATED POINT AND NONPOINT SOURCE LOADING IN THE SOUTH PLATTE AND MAJOR TRIBUTARIES

(pounds per day)

Basin	BOD_5		TDS		NH_3		PO_4		Fecal coliform[c]		Fecal streptococci[c]	
	NPS[a]	PS[b]	NPS[a]	PS[b]	NPS[a]	PS[b]	NPS[a]	PS[b]	NPS[a]	PS[b]	NPS[a]	PS[b]
Bear Creek	908	18	77,300	410	80	9	70	5	1,441,000	37,850	9,553,000	7,600
Cherry Creek	2,500	65	207,260	5,770	180	27	180	97	3,975,000	50,726	27,757,000	6,400
Sand Creek	5,500	108	445,000	9,700	450	108	400	86	8,851,000	36,600	55,814,000	7,200
Clear Creek	4,120	4,800	349,000	68,300	340	770	300	1,080	6,049,000	72.000	39,693,000	17,000
South Platte												
South Metro	2,600	4,900	220,400	78,600	200	1,810	190	860	3,934,000	83,300	21,760,000	26,500
Middle	8,500	485	712,400	10,600	670	240	630	130	11,741,000	15,100	77,346,000	3,800
Lower	4,260	36,000	321,000	667,600	320	18,100	310	7,300	7,673,000	22,800	48,057,000	3,800
Totals	28,328	46,411	2,332,300	840,980	2,240	21,054	2,080	9,558	43,664,000	318,370	279,980,000	72,300

Note:
a. Nonpoint source loading are 1970 levels as given in Reference 215.
b. Point source loadings are estimated from yearly average effluent flows and quality for major municipal treatment plants as input to the hydrocomp Model for 1972.
c. Values are in units of 10^6 per day.
d. Effluent levels estimated for Morrison sewage treatment plant.

Bear Creek Basin--Aside from occasional high temperatures in the headwaters and the aforementioned fecal coliform and streptococci problems, Bear Creek has levels of Phosphates higher than recommended for current goals for beneficial use. Table II-I data indicates that less than seven percent of this pollutant comes from point sources. The pollution problems that do exist on Bear Creek are caused by non-point sources. The data cited for this discussion do not include the effects of construction of Bear Creek Lake Dam near Morrison which probably is increasing suspended solids, TDS, and stream bed sediment loads.

Cherry Creek Basin--The water quality problems in this basin, other than FC and FS, occur below Cherry Creek Reservoir and are associated with high year round Phosphate and Ammonia levels, and high peak levels of TDS during runoff events. The Glendale Plant on Cherry Creek contributes significantly to the base flow of Cherry Creek which is in turn lowest during winter. Most of the point source loads for Ammonia and Phosphate in Cherry Creek come from the Glendale Plant. Plant source leads account for 13% of total Ammonia loads and 35% of total phosphate loads in the Cherry Creek basin. Removal of Phosphate from the Glendale plant effluent would improve water quality, but recommended levels for instream Phosphate levels would still be greatly exceeded. Removal of Ammonia from the plant effluent would be of limited value without non-point source reductions given the cost of reducing effluent levels below the current 5 mg/1. The high levels of TDS during runoff events reinforces the conclusion that this is essentially a non-point source problem. There is no current explanation as to why peak TDS levels are highest on Cherry Creek. It is suspected that the major source of TDS is Speer Boulevard which parallels Cherry Creek on both banks for over three miles downstream from Glendale. Discharges of roadway runoff carrying traffic generated pollutants and deicing chemicals into Cherry Creek may constitute a major non-point source.

Sand Creek Basin--The water quality problems associated with TDS, FC, and FS have been previously discussed and are principally a non-point source problem. The remaining major problems on Sand Creek involved Ammonia, Phosphate, and to a lesser extent BOD_5. Table II-I shows that the point source contributions are 20%, 18%, and 2% respectively of total basin loads on an average basis. However, during periods of low or intermittent flow, point sources strongly determine water quality in Sand Creek. The major point source on Sand Creek is the Aurora treatment plant and it contributes significantly to water quality problems during base flow conditions. Effluent levels in 1972 for Ammonia and Phosphate were 10 mg/1 and 8 mg/1 respectively. Reductions in these levels would benefit instream water quality, but recommended levels would still be exceeded.

Clear Creek Basin--The major causes of water quality problems associated with BOD_5, Ammonia, and Phosphates are the point sources discharging to

Clear Creek. Water quality in Clear Creek is determined by a complex interaction of seasonal flow variations, diversions, irrigation return flows, and discharges from wastewater treatment plants. Determining the importance of any one of these influences in any detail is not possible with existing information. Water quality modeling information from DRCOG's 208 investigation is available only for the headwaters above Golden, and at the mouth of Clear Creek.

There are five wastewater treatment plants discharging to Clear Creek. They are the Coors, Wheatridge, Clear Creek Valley, Arvada, and Crestview treatment plants. In 1972, the Coors plant effluent represented over 50% of total point source loads for Phosphates, 12% for Ammonia, and 60% for BOD_5. 1976 effluent monitoring data indicates about the same percentages for Phosphates and Ammonia, but that the BOD_5 now represents about 40% of total average daily point source loads.

The major diversions of irrigation water, some of which becomes part of municipal water supplies, occur below the Coors plant. Further downstream some additional diversions occur, but effluent from the other four wastewater treatment plants and irrigation return flows also occur. As a consequence, the influence of the Coors effluent on downstream water quality is seasonal, and is essentially significant only during those periods of the year when irrigation water diversions are small or nonexistent (generally November through March). The data in Table II-H illustrate this point. At the mouth of Clear Creek during the winter of 1972, the level of Phosphates was 3.2 mg/l; Ammonia, 4 mg/l; and BOD_5, 18 mg/l. During spring, summer, and fall, these levels were 1.4-1.7 mg/l for Phosphate, 1.2-1.5 mg/l for Ammonia, and 8 mg/l for BOD_5. These decreases are due to increased flow in Clear Creek causing dilution, instream processes which are temperature sensitive and which reduce flow carrying Coor's discharged pollutants. Thus, the downstream discharges from the other four wastewater treatment plants are a major cause of poor water quality in the lower half of Clear Creek during Spring, Summer and Fall.

South Platte--Point sources of BOD_5, Ammonia, and Phosphate clearly dominate over non-point sources in the South Metro portion of South Platte river (upstream from Bear Creek). These loads come from the Littleton and Englewood wastewater treatment plants. Although a new satellite plant to treat both Englewood and Littleton wastewater is under construction, these point sources will continue to dominate water quality in this portion of the South Platte river.

In the South Platte between Bear Creek and 38th Avenue (about one mile downstream from Cherry Creek), non-point sources clearly dominate. The discharge from the South Lakewood wastewater treatment plant does contribute significant quantities of Ammonia and Phosphate, but the water quality is already degraded because of discharges from the Littleton and Englewood plants.

The impact on water quality of the discharge from the Metropolitan Denver Sewage Disposal District No. 1 Plant is overwhelming on water quality in the South Platte downstream from the plant. This is not surprising considering the fact that about 40% of the total flow in the South Platte in 1972 was represented by the MDSSD No. 1 discharge. The percentage becomes 60-70% during winter low flow periods. As shown in Table II-I, pollutant loadings from the MDSSD No. 1 Plant represents about 75% of the total point and non-point Ammonia loadings in the entire Denver area. Comparable percentages for BOD_5 and Phosphate are 45% and 60% respectively. However, even if the MDSSD No. 1 plant discharged pure water, recommended levels of water quality in the South Platte would still be routinely exceeded.

Biology

Human settlement in the plains area has greatly change the local ecology of the Denver area through alterations in land use and the introduction of non-native vegetation and animals. Urbanization to a great extent has removed many wildlife habitat areas from the region. Despite these changes, several areas still retain much of their original steppe community characteristics. Other areas, modified by human land use have actually replaced some previously lost habitat and increased the diversity of the local environment. These are special habitat areas which are important to plant and wildlife ecology and do not tolerate great changes. A mapping of these sensitive areas is shown on Map F. Although there is a potential for several rare or endangered animal species in the area, none of the area's plant species are considered to be rare or endangered.

Within the Denver area, sensitive environmental areas are generally associated with watercourses and bodies. While major river and stream systems provide valuable wildlife habitat, the area's poor water quality limits the populations and species diversity of the area's wildlife. Channelization of streambeds has greatly reduced this habitat along some stream sections. Gravel pit ponds,, irrigation ponds, lakes and reservoirs provide important aquatic nesting, resting and feeding habitats for waterfowl and shore birds. The fringe areas of ponds and lakes, together with stream meanders provide intermittant march habitat for wildlife as well. Several heron rookeries are located in protected areas. Cottonwood and will groves creates gallery forests along watercourses which provide important wildlife refuge areas and visual relief from the surrounding flat plains.

In the outlying areas, human activity is less intense and many areas still retain much of their natural condition. Selected prairie-grassland areas show examples of the native vegetation and habitat prior to conversion to agriculture. Numerous prairie dog towns are found in areas removed from human disturbance and invasion by domestic animals. The historic range of the black-footed ferret which is protected by State and Federal regulations coincides closely with its prey species, the prairie dog. The changing prairie habitat and prairie dog control programs have indirectly, but strongly affected the black-footed ferret by reducing its prey. Of the larger grazing animals, black-tailed deer are somewhat tolerant to human presence and are often found in the lower foothills and grasslands area up to the periphery of developed areas. The formerly wide ranging pronghorn antelope are found in the upland grassland and prairie areas in the southern part of the study area. Elk and bighorn sheep are generally confined to the higher elevation forest and brushland areas, but do descend to critical wintering areas in the foothills during extreme winter weather conditions. Peregrine falcons, an endangered species, have been occasionally observed in the mountainous forest and brushland areas. The Denver plains area may have some value as a feeding range for the species. Within Colorado the white pelican is considered endangered as a nesting summer resident. White pelicans may be found at several reservoirs along the South Platte River. River otters are generally rare in Colorado and intolerant of human presence. Scattered sightings have been reported along the South Platte River drainage in Weld County outside of the Denver area.

Forest, brushland and prairie-grassland areas are important habitats which are susceptible to wildfires. The fire hazard is relatively much higher along the periphery of deveoped areas and rural roadways. The East Slope of the Front Range from piedmont areas up to approximately 2,424 m (8,000 ft) is considered to have the most severe fire potential.

Energy

In the Denver area nearly 75 percent of all petroleum products are consumed by the transportation sector compared to 50 percent nationally. Petroleum products represent 42 percent of the total energy supply utilized in the area which is comparable to the national percentage. The industrial, residential and commercial sectors of the economy have nearly 60 percent of their energy needs supplied by natural gas. Natural gas supplies 41 percent of the region's total energy demand whereas natural gas supplies about 31 percent of national energy demand. Projected shortfalls in supplies of natural gas will pose a constraint on growth after 1980. In the long term, increased reliance on coal-based electrical generation will force increased competition for available supplies of water which are necessary for coal mining and processing and air pollution abatement. Water, being a limited resource in the area at present, will become increasing more so in the future.

Historical Features

After becoming a part of the United States in 1803 as a result of the Louisiana Purchase, the natural resources of the Denver Region attracted fur traders, gold miners, ranchers and farmers. Following the discovery of lode deposits in the mountains in the mid and late 1800's, the region's population grew rapidly and the city of Denver became a cultural, political and financial center. The region's historical sites are concentrated and distributed in several areas reflecting the influences of major events such as the gold rushes and statehood. Sites concentrated along the edge of the mountains served as sources of supply and recreation for the mining populations. The concentration of sites in the Denver downtown area developed as Denver became the major supply point for the gold fields and eventually the state capitol. Out on the plains, sites are situated along the major cattle, stage coach and pony express trails which served the region before the advent of the telegraph and the railroad. Individual sites, mostly farm and ranch houses, are scattered throughout the plains area. Appendix Table A-8 lists the major historical sites in the Denver Region which are mapped on Map G.

Outdoor Recreation Sites

Several types of recreation areas such as the South Platte Greenway, a proposed trail system along major streams linked to the Greenway, and the Barr Lake and Barr Lake Duck Club are located near various existing and proposed wastewater facility sites (See Map G). Many of the recreation sites are located downstream from the Denver Metro Wastewater Treatment Plant. Some counties have acquired park and open space lands which are to be developed as populations grow over the next fifteen or more years. Numerous parks and open spaces are currently being planned or proposed by the cities of Littleton, Denver, Lakewood, Wheat Ridge, Arvada and Aurora. A major problem being experienced by the Denver area's park agencies is vandalism and misuse of park and open space areas. This problem may become more difficult to deal with in the future as service areas become larger and uses become more intense.

The recreational potential of most streamside parks, hiking trails, and bicycle paths is limited by current water quality problems.

Aesthetics

Amenities which make a strong contribution to the Denver region's quality of life include the temperate arid climate, visual relief from the high plains topography by the abrupt face of the Front Range, recreational potential of the Rocky Mountains, landscaped and semi-natural areas within the urban area, open space areas surrounding the city, and social, cultural and economic institutions which strongly govern urban life styles. Of these, visual and open space amenities are the least well-defined and also the most susceptible to change. Visual perceptions range from panoramic background views to areas of immediate perception to distinct scenic or contrasting features. Further high-rise development in central business districts can significantly alter these perceptions. Examples of well-known scenic features within the Denver Region are given in Appendix Table A-9, and their locations are shown on Map G. Open space can be described as land left undeveloped for the purposes of recreation, scientific study, protection of wildlife, watershed, or a buffer to urban encroachment.

Waste Land Disposal and Reuse

In many areas, sludge, the treated solid component of sewage, is sold or applied to city-owned parks and other green areas as a soil conditioner or disposed in landfills. The largest producer of sludge in the area, the Northside/MDSDD #1 wastewater treatment complex*, dewaters undigested sludge to reduce its volume and trucks it to the Lowry Bombing Range where it is mixed with soil. Because the high volume of sludge disposed at the range, this practice must be discontinued in the near future, and alternative plans are now being developed.

Improvements are under way and plans are being made to remedy the treatment complex's sludge disposal problems. Anerobic digesters are being constructed at the Denver Metro Plant that could eventually reduce the volume of sludge and make it more acceptable for land application. A long-range plan is being considered to transport sludge via pipeline to a drying distribution site in Western Adams County (see Figure II-J) for drying and subsequent sale to farms in the area. EPA has prepared a draft EIS on this plan. Plans for an airport in the vicinity of the site are being considered by Adams County.

Reuse of treated wastewater for urban and agricultural irrigation already occurs in the Denver region. Reuse is both direct and indirect. Direct reuse is the direct conveyance of treated wastewater

*This complex consists of two separate treatment plants. One is operated by the City and County of Denver, the other by the Metropolitan Denver Sewage Disposal District No. 1

from the treatment plant to point of use. Indirect reuse involves the exchange of treated wastewater discharged downstream for water diverted upstream which would normally be available for downstream users. Current and planned practices of direct and indirect reuse are more fully explained in Appendix A.

About 20,800 acre feet (6,800 million gallons) of treated wastewater is currently directly reused. The vast majority, about 19,900 acre feet per year, is used for agricultural irrigation after diversion from the MDSSD No. 1 plant to the Burlington Ditch by the Denver Water Board. This diversion represents about 14 percent of the total yearly discharge of the plant. A portion of the effluent conveyed to Barr Lake contributes to the water quality problems of that recreational and wildlife area. The remaining 900 acre feet is used for urban irrigation of parks and golf courses. The cities of Northglenn and Westminster are currently completing arrangements for direct reuse of treated wastewater for agricultural irrigation in exchange for upstream diversions of water for municipal use. Also, Denver is planning to construct a 1.0 million gallon per day pilot treatment plan for producing potable water from wastewater effluent. Ultimate plans are for a 100 million gallon per day plant if safety consideration and public acceptance permit.

All reuse schemes are in effect a means of increasing water supply. They may also have the potential of improving stream water quality by diverting relatively polluted discharges from streams to some reuse such as irrigation. Water quality "benefits" are sometimes difficult to define because a substantial portion of the flow in a particular stream, such as Cherry Creek, may depend on point source discharges. Benefits from improved quality in terms of pollutants may be offset by diminished flow. The communities in the Denver region are interested in reuse schemes because they stretch or augment existing water supplies. This interest will continue and intensify.

In effect, the waters of the South Platte are used many times by municipalities and agriculture before reaching the Nebraska State line. A situation not uncommon on most major rivers of the United States.

Traffic

In 1974, 97% of all intracity trips in the region were made by automobile. The existing highway system become overloaded at peak traffic times in several areas and the situation is expected to worsen due to further population growth and suburban development patterns and locations. The nature of these overloaded conditions is generally a reduction of traffic flow speeds by 10-30 mph. Although the "linear parking lot" traffic jam situation typical of other major cities such as New York and Los Angeles is rare in Denver, it is not an unheard of occurrence. Some of the major highways and arterials presently experiencing rush hour overload conditions include:

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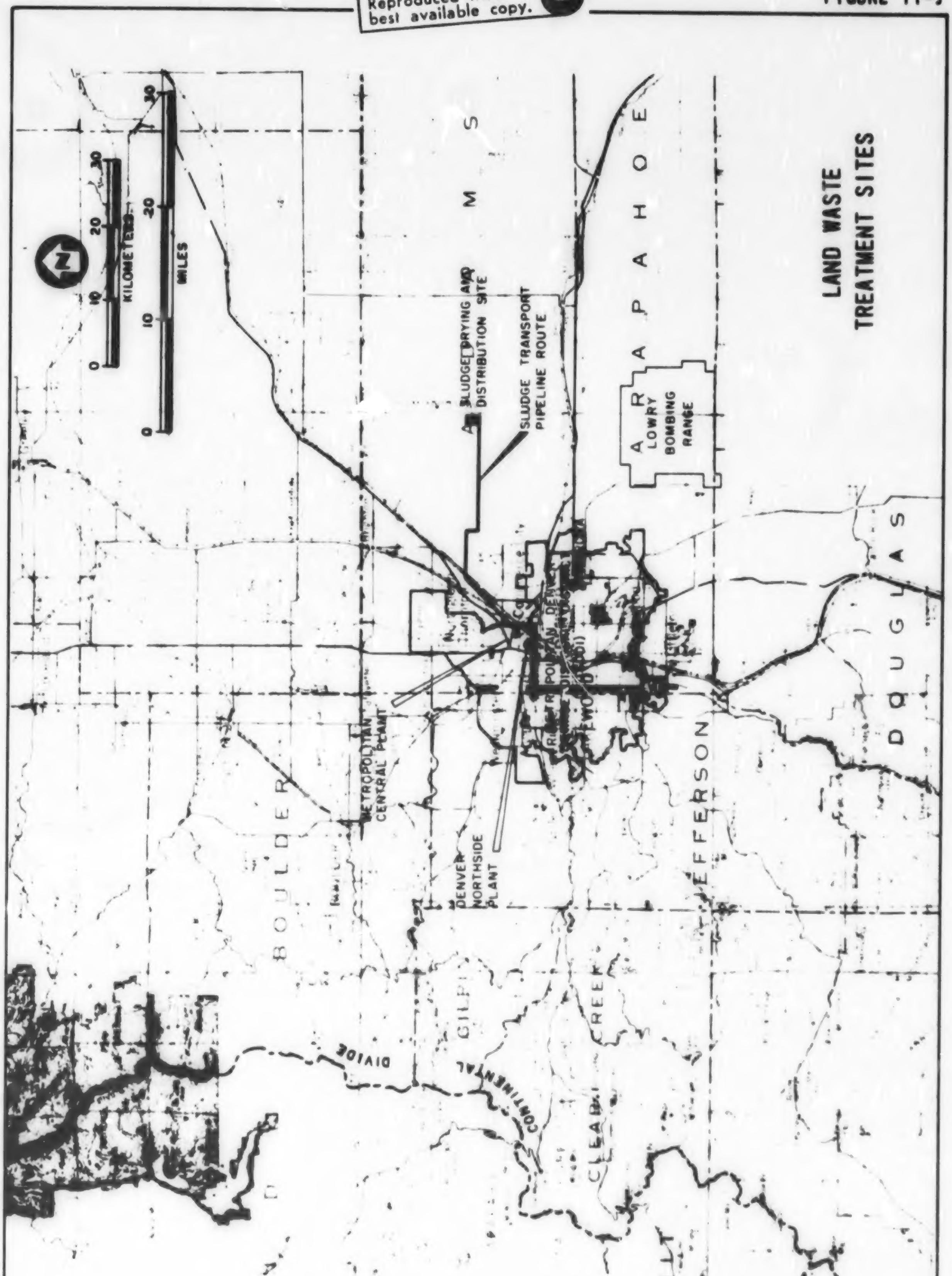
FIGURE II-J



LAND WASTE TREATMENT SITES

KILOMETERS
0
10
20
30
MILES
0
10
20
30
N
BOULDER
ADAMS
ARAPAHOE
DOUGLAS
JEFFERSON
GILPIN
CLEAR CREEK
CONTINENTAL DIVIDE
SLUDGE DRYING AND DISTRIBUTION SITE
SLUDGE TRANSPORT PIPELINE ROUTE
LOWRY BOMBING RANGE
METROPOLITAN CENTRAL PLANT
DENVER NORTHSIDE PLANT

1. Broadway Avenue from the Central Business District (CBD) to Englewood.

2. I-25 (Valley Highway) from the Denver-Boulder Turnpike Interchange south past U.S. Highway 6.

3. The I-70/I-25 interchange nicknamed the "mousetrap."

4. Federal Boulevard, Speer Boulevard, Alameda Avenue, and Santa Fe Drive as they approach the CBD.

5. Wadsworth Boulevard, Hampden Freeway, Sheridan Boulevard and Colorado Boulevard as they approach the major thoroughfares carrying traffic in and out of the CBD.

Present attempts to remedy traffic problems include further highway construction such as that being planned in the southwest area of the region to relieve traffic congestion. Also, various types of mass transit systems are being studied by the Regional Transportation District (RTD).

Plutonium Contamination

The extent and significance of plutonium-in-soil and airborne contamination caused by the plutonium processing plant at Rocky Flats is under intense investigation by State and Federal agencies. Various agencies are concerned that plutonium contamination may have occurred as a consequence of the fire at the Rocky Flats Plant in 1969. The transport of plutonium contamination easterly from the plant is known to have occurred. Whether contamination levels are hazardous to human health has not been decisively determined. Investigations are now underway to determine the extent of contamination of the ground surface, Great Western Reservoir, Standley Lake, and whether wind pickup of surface contamination represents a hazard. Ultimately, certain land areas generally east of Rocky Flats may be banned from residential development.

SOCIO-ECONOMIC ENVIRONMENT

The term "socio-economic" embraces all those conditions and activities that relate to man's habitation and use of his environment. Housing, employment, community services and facilities, and the institutional structure through which demands for these good and services are communicated all form part of the socio-economic setting. This section presents first basic data on the regional economy, population and land use. Subsequent sections discuss community services and facilities, agricultural land use, and regional planning and policies.

Regional Economy, Population and Land Use

The Economy--

The Denver region enjoyed a significant economic expansion in the past three decades, and particularly in the 1960's. Employment in all major nonagricultural sectors of the region's economy grew at a faster rate than in the nation during the second half of the 1960's and are expected to continue to surpass national growth through the 1970's (Ref. 905). During the 1940-1970 period, employment in the five-county Denver region increased at an average rate of 3.7% per year, while state and national employment grew at rates of 3.0% and 1.7% respectively (Ref. 259). In 1970, about 60% of Colorado employment was located in the five-county Denver region.

In 1975, nonagricultural employment in the Denver region numbered about 661,400. About 65% of these jobs were concentrated in three section: trade, services and government (including military). Denver's economic mix is more strongly concentrated in the service-producing sectors than in the goods-producing sectors. In the U.S. as a whole, 23.8% of nonagricultural employment is in manufacturing; in Denver, the comparable proportion is 14.3% (Refs. 999 and 259). However, a few manufacturing activities are significant exceptions. Machinery,electrical products, luggage and rubber manufacturing are considered major contributors to the "exports" of the Denver region; that is, economic activities which result in the sales of products to markets outside the region. With these exceptions, however, most of Denver's export activity is in the service sectors: TCU (transportation, communications and utilities), trade, services and FIRE (finance, insurance and real estate). Employment concentration in these sectors reflects Denver's role as a regional finance and distribution center for the mountain states.

Recent trends in employment suggest that strength in the service sectors is becoming more marked. While there has been significant growth in all economic sectors since the mid-1960's, growth in trade, FIRE and services has been much more rapid than in manufacturing, as Table II-J indicates. However, construction employment continues to grow quite rapidly - a tangible indicator of growth in all sectors.

A significant recent trend in employment growth is in the mining sector. This sector includes extraction of minerals occurring naturally (coal andores, liquid petroleum and natural gas), quarring, well operation-exploration and development, and related off-site employment. Much of the growth in downtown office employment in the Denver region in recent years is reprotedly in the extractive industries, with a number of major firms using Denver as the base from which to supervise exploration and energy development activities in the mountain states. This trend has created a surge in demand for downtown office space, which has been experiencing very low vacancy rates; downtown office construction is expected to continue to prosper, at least in the short run (Trenka, pers. comm.).

The distribution of employment among the counties of the region has been changing over time: as the four outer counties have urbanized, Denver (City and County) has represented a decreasing share of the region's employment. Figure II-K depicts shifts in county shares graphically.

Population--

In recent years, Denver has been one of the nation's fastest-growing metropolitan regions. During the 1960's, the Denver metropolitan area grew annually between 3% to 4.6%, considerably more rapidly than the state's 2.3% average annual growth. Over half of Colorado's population lives in the five-county region (Ref. 304). Figure II-K presents a graphic depiction of the distribution of the region's population by county in 1960 and 1970. Table II-K presents demographic characteristics of the Denver region's population in 1970.

Population growth is composed of two elements: the excess of births over death ("net natural increase') and the excess of in-migrants over out-migrants while death rates remained fairly stable, birth rates have dropped over 40% since 1960. A majority (60% in 1975) of the total population increase in the Denver region is attributable to net in-migration. Table II-L presents county estimates of population change of both types in 1975.

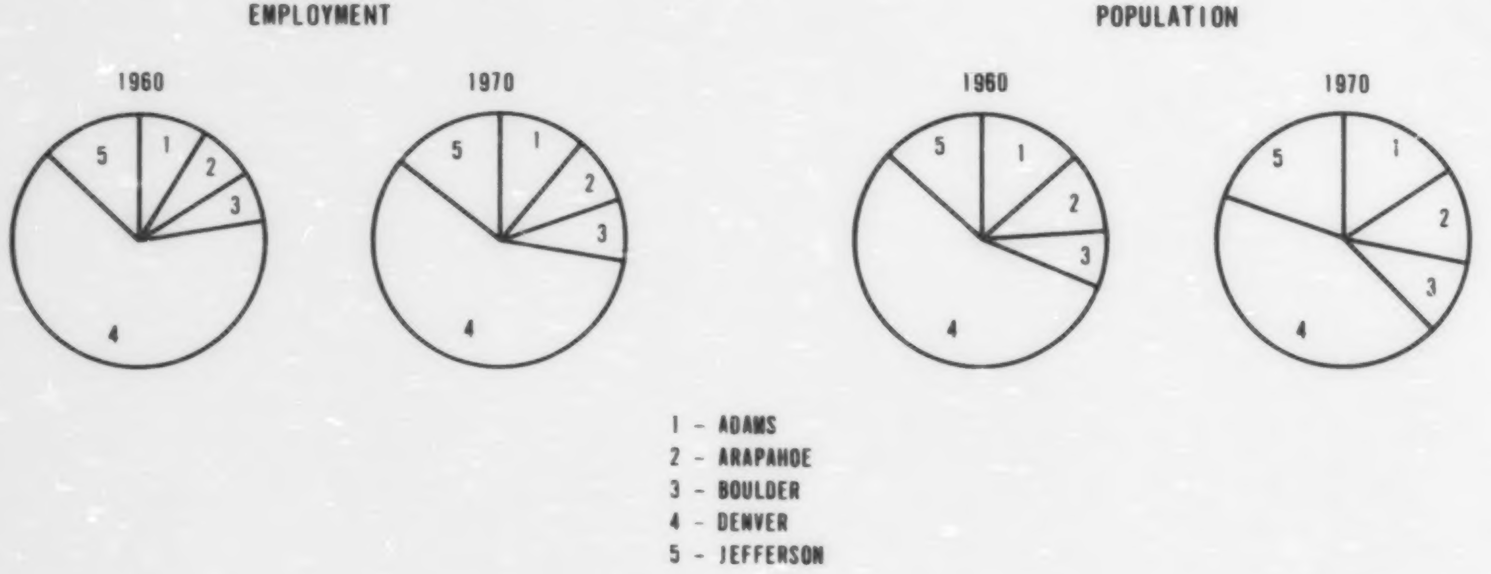
In the period from 1940 to 1970, annual net in-migration to the region averaged 15,100 (Ref. 401). Recent years have seen the suburban counties - particularly Jefferson-attracting the lion's share of net in-migrants, as Table II-M indicates. It should be kept in mind, however, that net migration figures do not reflect total movement. The City and County of Denver may be receiving a large absolute number of newcomers, but its loss of residents to the suburban counties may exceed the number of new residents it receives from outside the region, at which point its absolute population declines.

Table II-J. RECENT TRENDS IN NONAGRICULTURAL EMPLOYMENT BY SECTOR IN THE FIVE-COUNTY DENVER REGION

Sector	Annual Growth Rates, % 1964-70	Annual Growth Rates, % 1970-75	Current Employment
Mining	2.8	5.7	7,800
Construction	3.6	5.6	42,500
Manufacturing	4.7	1.7	94,700
TCU (transportation, communications and utilities)	3.0	2.3	42,100
Trade	4.5	4.8	161,600
FIRE (finance, insurance, real estate)	4.1	6.9	44,900
Services	5.9	5.4	143.400
Government (including military)	4.4	3.9	124,400
Total Nonagricultrual Employment	not tabulated	4.2	661,400

Source: DRCOG. Figures for 1964-70 cited in Ref. 304 and figures for 1970-75 cited in Ref. 259.

FIGURE II-K



REGIONAL EMPLOYMENT
AND
POPULATION BY COUNTY[a]

[a] EXCLUDES EASTERN ADAMS AND ARAPAHOE COUNTIES AND WESTERN BOULDER COUNTY. SOURCE: REF. 262.

Table II-K. DEMOGRAPHIC CHARACTERISTICS OF DENVER SMSA[a] POPULATION, 1970

Family Income Categories	Number of Families	&	Age Categories	Persons	%	Major Ethnic Groups	#	%
<$3,743[b]	20,572	6.8	<15	362,195	29.5	White	1,021,477	84.6
<$4, 999	43,172	14.2	<19	477,904	38.9			
$5,000 to $14,999	185,713	61.0	20 to 54	564,078	46.0	Spanish surname	138,928	11.3
>$15,000	75,580	25.0	>55	185,547	15.1			
			>65	95,046	7.7			
Median	$10,777		Median	ca. 26.5		Black	50,159	4.1

a. Denver SMSA in 1970 includes Adams, Arapahoe, Boulder, Denver and Jefferson Counties.
b. Poverty level.
<, means less than
>, means greater than
Source: Ref. 304

Table II-L. COMPONENTS OF ESTIMATED RESIDENT POPULATION CHANGE, 1975

County	Births	Deaths	Net Natural Increase	Net In-migration	Total Increase
Adams	3,721	1,110	2,611	389	3,000
Arapahoe	2,880	1,060	1,820	5,280	7,100
Boulder	1,965	879	1,086	3,614	4,700
Denver	6,468	4,918	1,550	-4,950	-3,400
Jefferson	4,289	1,578	2,711	12,289	15,000
TOTAL	19,323	9,545	9,778	16,622	26,400

Source: Ref. 208

Table II-M. DISTRIBUTION OF NET IN-MIGRANTS TO FIVE COUNTIES, 1970-72

Year	Adams County	Arapahoe County	Boulder County	Denver County	Jefferson County
1970	20.0%	18.2%	13.8%	2.3%	45.7%
1971	19.5	24.1	16.4	2.7	37.3
1972	13.3	25.9	16.5	1.5	42.8

Source: Ref. 128

The general pattern of population change in the region has been that of a central city (Denver) representing a declining proportion of the region's population. Since 1960, the population of Denver (City and County) has grown more slowly than at any other time in the twentieth century. One study points to the increasing resumblance between Denver's patterns of population change and those of older urban core cities, especially in the East and Midwest:

> The overall picture presented is one of Denver as an aging urban core city increasingly populated by the poor; the less educated; the minorities; the less easily employed; the elderly; and the working young adult households. It is also one of Denver surrounded by a solid suburban ring populated by the white majority; the affluent; the better educated; the family households with children and with adults in their most productive years; and the higher skilled and more easily employable. (Ref. 905.)

In-migrants to Denver tend to be the elderly, minorities, and young adults: this pattern may be accompanied by higher employment, lower levels of educational attainment and lower household incomes. The pattern will cause the existing social dichotomy between core city and suburb to become more pronounced over time.

Land use--

The most striking characteristic of regional land use is its dispersed pattern and lwo density. In the City and County of Denver, population density was about 5,418 persons per square mile in 1970, with about 200 persons per square mile in the four suburban counties for an SMSA average of 335. Of the 34 metropolitan regions having populations exceeding 500,000 in 1970, only five (Dallas-Fort Worth, Houston, San Diego, Riverside-San Bernardino, and Portland) had lower densities. In fact, population density in the Denver region was less than that in many suburban counties of other regions. Isolation from other urban areas, preference for open space and the high mobility made possible by the extensive highway network are reasons given for the overall suburban density of this urban region (Ref. 304).

Growth in recent years has shifted the distribution of many land use categories from the City and County of Denver to the outlying counties. In the case of single-family residential, the regional concentration of this development shifted to Jefferson between 1960 and 1970. Multi-family housing, too, has increasingly been a suburban phenomenon, and retail/service commercial activity has followed the shift in population. Suburbanization of major industry has begun recently and is expected to continue (Ref. 905). Agricultural land use declined by about 7%; this decline is discussed in Section IV. Table II-N presents a land use tabulation by county for 1960 and 1970.

Many local officials have observed that land use patterns in the region have thus far developed more in response to economic pressures than as the result of conscious planning. This has occurred in part because existing zoning is in conflict with the regional plan: while a regional population forecast of 2.35 million has been adopted, DRCOG found in 1972 that the population holding capacity of zoned land exceeded six million. The study of existing zoning concluded that the region was greatly overzoned; "at present, every city and county has zoning far in excess of that needed to accommodate its present population" (Ref. 258).

Under these circumstances, zoning has not been an effective tool in implementing land use planning. Much of this overzoning is reported by local jurisdictions to have been the result of pre-zoning when annexations took place. As a practical matter, rezoning cannot easily be accomplished until the land is proposed for development, and even then rezoning may not be possible. Many local public officials interviewed in the course of this study expressed the view that a state law requiring zoning to be consistent with comprehensive planning would help to solve this problem; however, some also pointed to the common acceptance of the zoning map as the community comprehensive plan. No ready solution to the over-zoning problem was identified.

Table II-N. COUNTY LAND USE SUMMARY, 1960 AND 1970
(1000 acres)

County[a] & Year	Single-family	Multi-family	Commer-cial	Ser-vices	Industrial, Transporta-tation & Com-munications	Parks & Recrea-tion	& Semi-public	Agricul-tural	Vacant	Total
Adams										
1960	6,266	265	482	54	10,813	320	18,676	189,542	16,590	
1970	9,947	928	994	177	14,155	1,173	18,642	177,241	19,751	243,008
Change	+ 59%	+250%	+106%	+228%	+ 31%	+267%	0%	-6%	+19%	
Arapahoe										
1960	6,688	343	360	120	7,990	4,642	13,077	80,161	13,428	
1970	11,797	653	760	310	10,190	5,187	7,760	74,923	15,229	126,809
Change	+76%	+90%	+111%	+158%	+27%	+12%	-41%	-6%	+13%	
Boulder										
1960	5,935	382	564	72	7,510	46,897	3,128	138,958	79,474	
1970	9,775	951	910	153	9,236	47,781	3,781	133,867	76,466	282,920
Change	+65%	+149%	+61%	+112%	+23%	+2%	+21%	-4%	-4%	
Denver										
1960	15,146	2,306	1,253	539	19,781	3,079	4,802	7,403	9,122	
1970	16,918	2,998	1,672	613	23,000	3,559	3,813	1,965	8,873	63,431
Change	+12%	+30%	+33%	+14%	+16%	+16%	-21%	-73%	-3%	
Jefferson										
1960	11,325	411	638	951	13,738	125,497	6,059	76,867	262,680	
1970	18,148	892	1,338	966	17,834	128,127	6,648	71,335	252,878	498,166
Change	+60%	+117%	+110%	+2%	+30%	+2%	+10%	-7%	-4%	
Total[a]										
1960	43,360	3,707	3,297	1,736	59,832	180,435	45,742	492,931	381,294	
1970	66,585	6,422	5,674	2,219	74,415	185,827	40,644	459,351	373,197	1,214,334
Change	+47%	+73%	+72%	+28%	+24%	+3%	-11%	-7%	-2%	

[a] Excludes western Boulder and eastern Adams and Arapahoe Counties.

Source: Ref. 205

Community Services and Facilities

A wide variety of government services are provided by local jurisdictions in the Denver region. These jurisdictions include 25 municipalities and 201 special service districts within the four-county region (Adams, Arapahoe, Denver and Jefferson Counties). A recent study of taxation and finance in the region (from which the data in this section are taken) found that these jurisdictions spent approximately $920 million in 1974 ($747 per capita) as compared with total revenues to the State of Colorado of $958 million in fiscal year 1974-75 (Ref. 987).

The major local cost is for public education, which ranges from $232 (Denver) to $320 (Arapahoe) per capita; total county per capita expenditures (that is, total expenditures of all local service agencies and municipalities within county boundaries) ranged from $571 (Jefferson) to $835 (Denver) per capita. The service ranking second in per capita cost is water and sewerage. For a number of reasons, including the fact that costs paid to private water and sewerage agencies are not included in the estimates of public costs, average water/sewerage costs were found to vary widely throughout the Denver region. Compared to a regional average of $70 per capita, the county average (1974) are $92 (Adams), $75 (Arapahoe), $60 (Denver), and $48 (Jefferson). Among municipalities, even greater variability was observed: Commerce City has per capita water/sewerage costs of $142; Englewood, $93; Golden, $66; Arvada, $46; Wheatridge, $28.

The Denver Metropolitan Study report on finance and taxation (Ref. 1005) considers several issues related to revenue, expenditure and service delivery organizations. On the question of distributional equity (taxation burden relative to ability to pay), the study found that the City and County of Denver, with 43% of the population in the four-county region, accounts for 42% of the gross personal income. "This suggests that on the aggregate the City/County is not seriously disadvantaged in terms of ability to pay as measured by gross personal income." The study did point to a disparity among counties in terms of personal income per capita; Arapahoe, $4994; Jefferson, $4718; Denver, $4260; Adams, $3516. "The real disparity within the region is between Adams County and the other three counties."

A second important issue is that of the organization of service delivery. The 201 special districts in the four counties account for 10% of all local revenues. Because these districts cut across municipal, county and other special service district boundaries, they make efficient planning and administration of services extremely difficult. Even obtaining information from such districts (one-third have no paid staff) proved very difficult to the Metropolitan Study research team. The study concluded that fractionated districts (1) make accountability uncertain; (2) result in higher costs and (3) involve double taxation. It is the special district system which is responsible for the wide variation in municipal property taxes, with the resulting unevenness in the cost of public services to individual taxpayers.

Table II-O present a summary of user and service charges imposed by the local agencies proposing new wastewater facilities.

South Adams County Water and Sanitation District (SAS)--

The majority of SAS's funds in 1970 came from service charges (46.7%) and a mill levy (47.0%). Most of the remainder of the funds were tap fees and interest, with smaller amounts produced by special improvement charges, plant investment fees, special assessments, inclusion fees and permit fees (tax inspection). SAS charged a $200 tap fee per unit in 1972 and a monthly residential service charge of $2.00 per unit. The district had general obligation bonds outstanding in 1973 which were scheduled to be retired that year (Reference 120).

Cities of Littleton and Englewood--

Both cities receive funds from service charges and tap fees. In addition, Littleton receives funds from interest, special improvement charges and special assessments. Englewood charges a plant investment fee and has a tap inspection fee. Englewood has a tap fee of about $100 for residents and $115 for non-residents based on square footage or acreage. Littleton's residential tap fee is per unit and is typically $300 for residents and $450 for non-residents. Englewood's per unit service charge is $1.25 for residents and $1.75 for non-residents. Littleton service charges are a percent of a unit's water bill. The average monthly charge is $2.90. Englewood currently has refunding revenue bonds outstanding.

City and County of Denver (CCD)--

CCD receives almost all its revenue (95.4%, 1970) from service charges. The remainder comes from interest and special improvement charges. CCD does not charge a tap fee. The service charge is based on a percent of the water bill. Service charges averaged $3.25 per month for residents and $3.08 per month for non-residents in 1972 (Reference 120).

In 1972, CCD sold $20 million worth of general obligation bonds. These obligations are binding on the entire city and county, not just the Wastewater Division. It is presumed some or much of

Table II-O. SUMMARY OF AVAILABLE INFORMATION ON USER CHARGES

Agency	Facility Plan service area/project	User charge rate structure						Remarks
		Service charge			Tap fee			
		Residential	Commercial	Industrial	Residential	Commercial	Industrial	
South Adams County Water and Sanitation District	South Adams	$2.80/mo[a]	$2.80/mo[a] + 25% of water charges above $3,000 gal.	percent of metered water consumption[b]	$235/unit[a]	per unit[b]	per unit[b] (negotiable)	received ~ 47.0% of revenue from mill levy in 1972[b]
City of Littleton	Littleton/Englewood	$2.75/mo[a] % of water bill[b]	$2.75/mo[a] per equivalent dwelling unit	meter size[b]	$300/unit[a]	per sq ft[b] or negotiated	negotiated	
City of Englewood		$1.25/mo[a] within city $1.75/mo[b] outside city	$1.25/mo[a]	% of water bill[b]	$300/unit[a]	per sq ft[b] or acreage	per sq ft[b] or acreage	
City and County of Denver, Wastewater Division	Cherry Creek/ Goldsmith Gulch Northside Plant	101% of water bill; water rate = $.38/1,000 gal.[a]	95% of water bill[a]	% of water bill[b]	$300/unit[a]	none[b]	none[b]	
Metropolitan Denver Sanitary Disposal District #1	Lower South Platte Clear Creek Sand Creek main plant expansion	-	-	-	-	-	-	MDSDD#1 charges user on following basis[c]: flow @ 45.51% BOD @ 30.68% SS @ 23.61%
City of Broomfield	Big Dry Creek	$3.50/mo[b]	per unit[b] + % of water bill	per unit[b] + % of water bill	$580/unit[a]	per unit[b]	per unit[b]	
City of Westminster		$3.00/mo[a] within city $3.50/mo outside city	$.35/1,000 gal. water used[a]	negotiable contract[b]	$455/unit[a]	per pipe size	per pipe size	
South Lakewood Sanitation District		none	none	none	$401/unit[d]	-	-	4.16-mill levy for general revenue

[a] Reference 976 [b] reference 120, 1972; [c] reference 328, 1976; [d] personal communication, John Krus, 8 February 1977.

this capital was used to fund the plant improvements to the Northside plant which are now being completed.

Metropolitan Denver Sanitary Disposal District No. L (MDSDD #1)--

All income is based on charges to other district using MDSDD #1's treatment facilities. Charges are based on volume and wastewater characteristics. The district meets all operating and maintenance costs and payments on long term debts, which consists primarily of revenue bonds, from these charges. A small amount of income is derived from interest on unused capital.

Cities of Broomfield and Westminster--

Both cities receive all of their revenues from service charges, tap fees and interest. Both had revenue bonds outstanding in 1973 (Reference 120). Broomfield has a tap fee of $150 which includes a plant investment charge. The fee is the same for both city and non-city residents. Westminster charges a $180 tap fee for city residents and $270 for those outside the city. Broomfield charges industrial and commercial users an undisclosed flat unit rate while Westminster charges per pipe size. Broomfield's service charge is $3.50 per month for all residential users. A flat rate plus a percent of water bill is charged to industrial and commercial users. Westminster charges flat rates of $3.00 per month for city residents and $3.50 per month for non-residents. Commercial and industrial users' rates are based on water use or negotiations between the city and individual user.

South Lakewood Sanitation District (SLSD)--

South Lakewood Sanitation District receives revenues from two sources, a tap fee of $401 per unit and an ad valorem tax of 4.166 mils (Ref. 966). Current treatment costs for operating and maintenance have been reported to be $230-240 per million gallons (Ref. 967). SLSD currently has no service charge. As there is little industry in the district, SLSD officials hope that legislation will be passed to permit continued use of ad valorem taxes to finance the local share of wastewater facilities costs. If such legislation is not passed, the district would consider changing to a service charge revenue system in order to qualify for Federal grant money. SLSD has no outstanding bond issues.

Agricultural Land Use

Land in Agricultural Use--

The fringes of the Denver Metropolitan area contain a great proportion of highly productive farmland. Soils are generally deep, friable, well-drained, flat and fertile. Table II-P shows a total of 301,790 acres (1973) of existing prime and non-prime agricultural land in the areas likely to experience growth pressures before the year 2000. The figures shown are for the Denver Regional Council of Government's (DRCOG) "empiric counties", i.e. those urban and urbanizing portions of the political counties in the region which provide the areal basis for population projections.

Table II-P: 1973 ESTIMATES OF AGRICULTURAL ACREAGE BY EMPIRIC[a] COUNTY IN THE DENVER REGION

County	Rangeland	Non-Irrigated Cropland	Irrigated Cropland	Total Agricl. Lands[b]
Adams	10,750	16,070	32,790	59,610
Arapahoe	38,940	20,550	830	60,320
Boulder	30,000	10,950	74,120	115,070
Denver	3,470	1,100	2,510	7,080
Douglas	0	0	0	0
Jefferson	41,540	10,750	7,420	59,710
Weld	0	0	0	0
TOTAL	124,700	59,420	117,670	301,790

[a] Empiric County boundaries designated by DRCOG, 1973

[b] Total Agricultural lands within Empiric Counties (Reference 257)

Table II-Q shows a total of 392,040 acres (1973) of existing prime and non-prime agricultural lands in the region beyond the boundaries of the empiric counties. More simply stated, Table II-N is an estimate of agricultural lands in the region which are not expected to experience significant pressures to convert to urban uses before the year 2000.

Table II-Q: 1973 ESTIMATES BY POLITICAL COUNTY OF EXISTING AGRICULTURAL LAND WITHIN THE REGION'S MAJOR DRAINAGE BASINS,[a] BUT OUTSIDE THE EMPIRIC COUNTY BOUNDARIES

County	Rangeland	Non-Irrigated Cropland	Irrigated Cropland	Total Agricl. Lands
Adams	0	2,790	41,470	45,260
Arapahoe	0	24,130	11,410	35,540
Boulder	51,300	8,230	4,120	63,650
Denver	0	0	0	0
Douglas	137,560	34,960	7,700	180,220
Jefferson	41,140	10,300	1,720	53,160
Weld	1,430	3,540	9,240	14,210
TOTAL	231,430	84,050	75,660	392,040

[a] Major drainage basin boundaries designated by DRCOG, 1973

[b] Total agricultural lands outside of empiric counties, but within the region's major drainage basins (Reference 257).

Using published and other available soils information, the "prime" agricultural lands, i.e. those lands having the fewest limitations for various agricultural uses, were mapped as shown on Map D. This map was prepared principally for regional impact assessment. Criteria used to determine prime lands included the U.S. Soil Conservation Service soil capability rating and predicted crop yields. They did not include such site-specific variables as economic feasibility and value, land ownership, and energy requirements for crop production. These criteria for both irrigated and dryland operations were mapped as accurately as the available soil maps permitted. Areas currently in urban development were excluded from consideration. However, current zoning and political boundaries did not influence the mapping.

At the present time, most of the existing croplands mapped as prime are under irrigation as evidenced from recent satellite photography. See satellite photo included in Map folder.

Using a tabulation of soils types and their acreages by county, DRCOG has estimated that there are 773,017 acres of existing and potential prime agricultural lands in a three county area which extends beyond the study area to the west into the mountains of Boulder County and to the east out into the plains of Adams and Arapahoe Counties. This sum figure for prime lands is based on the total acres of soils which qualify for classification as prime agricultural land according to preliminary criteria adopted "for discussion purposes only" by DRCOG. Table II-R summarizes the tabulation. It is presented in its entirety in Appendix A.

Table II-R: SUMMARY OF DRCOG TABULATION OF EXISTING AND POTENTIAL PRIME AGRICULTURAL LANDS IN A THREE COUNTY AREA OF THE DENVER REGION

County	Number of Acres
Adams	450,000
Arapahoe	229,797
Boulder	93,220
Denver	Not applicable
Douglas	Insufficient data
Jefferson	" "
Weld	" "
TOTAL	773,017

(Reference 252)

The Economic Value of Agricultural Activity--

Denver is a major agricultural and livestock trading center. Beef cattle dominate the livestock market, while major crops include alfalfa, small grains, corn and sugar beets (Ref. 104).

Agriculture accounts for 6% of the region's employment (as compared with 3.5% of the nation's employment) (Refs. 994 and 995). In terms of crop values, the most important single crop is winter wheat which in 1974 accounted for almost 43% of the value of regional crops, as indicated in Table II-S.

TABLE II-S: VALUE OF CROP POPULATION BY COUNTY, 1974
(in 000's of Dollars)

County	Winter Wheat	Corn (Grain & Silage)	Hay	Sugar Beets	All other Crops	Total
Adams	13,329.0	3,458.0	2,359.5	1,333.0	3,866.2	24,345.7
Arapahoe	4,070.0	394.3	718.1	-------	601.5	5,783.9
Boulder	706.6	3,357.0	2,219.0	2,390.0	2,694.2	11,366.8
Jefferson	293.4	136.0	829.5	-------	369.0	1,627.9
TOTAL	18,399.0	7,345.3	6,126.1	3,723.0	7,530.9	43,124.3

Source: Ref. 984

Agricultural activity in the region creates jobs in other sectors of the economy, as Denver region firms in such sectors as manufacturing, finance and trade provide goods and services to agriculture. One study traced the economic effects of agricultural activity on irrigated lands in Adams County and found that 100 agricultural jobs create the demand for 82 nonagricultural jobs, with the majority of these in the manufacturing and service sectors (Ref. 986). This estimate includes only the direct economic effects of agriculture; it excludes job generated within each nonagricultural sector due to demand by other nonagricultural sectors for goods and services needed to meet requirement of agriculturalists. If all these inter-and intra-sectoral economic linkages were qualified, the result would be an estimate of an agricultural "multiplier" for the Denver region: a measure of the total economic impact of regional agriculture on the regional economy. No research on this subject was found; however, for the State of California, an agricultural multiplier has been estimated as between 3 and 4, meaning that for each $1 of agricultural production, the state enjoys $2 to $3 of additional economic product related indirectly to agriculture (Ref. 991).

Future Prospects for Regional Agriculture--

Denver's role as a regional center of finance and trade will permit it to continue to capture agriculture-related jobs in non-agricultrual sectors even as agricultural activity becomes increasingly distant from Denver due to urbanization and other factors. Loss of agricultural employment in the five-county regions is a reasonable expectation. DRCOG forecasts that this decline will be on the order of about 12% between 1975 and 2000 (Ref. 259). This need not necessarily mean loss of production, as historically productivity increases have more than made up for reductions in farm labor. However, loss of agricultural land or water supply to urban uses may result in a decline in agricultural output.

Much of the Denver region's growth since 1950 has taken place on land formerly in agricultural production. In Adams and Arapahoe Counties in the 1960's, about 56% of the gross addition to urban land came out of the cropland category (Ref. 719). Notwithstanding the conversion of agricultural land to urban uses, the total acreage in cropland did not decline, because land in other open land categories (principally pasture and range land and open idle land) was converted to cropland. However, total land in the agricultural category did decline 33,580 acres or 7%. Similar patterns have been noted in other regions (Ref. 719 and 127).

Indirect effects of growth are causing further pressures. These indirect pressures are manifest principally through increases in the cost of water and the increased demand for water by municipalities. This latter point is illustrated by the current condemnation proceedings initiated by the cities of Thornton and Westminster to affect conversion of agricultural irrigation water rights to municipal use. Loss of water would probably result in the conversion of irrigated cropland back to dry land farming and grazing, increased land speculation, and an overall decrease in productivity and amount of land in agricultural production. Coupled with these pressures, the current drought, and the unsatisfactory returns on cultivated land farmers have experience in the last few years, are causing serious difficulties for the agricultural sector of the region's economy. The prognosis is not favorable.

Regional Planning Policies

Regional planning for the Denver Metropolitan area has had an interesting and sometimes even turbulent history. Until very recently, land use and transportation planning were done jointly by an organization known as the Joint Regional Planning Program or JRPP. The three participants in this program were the State Division of Highways (CDH), the Regional Transportation District (RTD), and the Denver Regional Council of Governments (DRCOG).

Early in 1977, the DRCOG was designated as the Metropolitan Planning Organization by the Governor and, as such, is now responsible for transportation planning. Additionally, DRCOG has had a history of being the regional land use planning and population forecasting body and also provides many other regional planning functions. The Denver Regional Council of Governments represents 37 local governments throughout the metropolitan area. In 1973, DRCOG adopted a Year 2000 regional land use plan (see Map I) along with a set of policies which outline the population and land use guidelines for growth in the region. (See Appendix A). One of the most significant of these policies is the statement that:

> A population level below 2,350,000 should be encouraged for the Denver Metropolitan Statistical Area by the year 2000.

The Council of Governments is also the designated agency responsible for water quality management planning in Denver under Section 208 of the Federal Water Pollution Control Act of 1972. In developing this water quality plan, the DRCOG adopted an allocation by municipality of the Year 2000, 2.35 million population forecast.

Another agency responsible for regional water planning in the metropolitan area is the Urban Drainage and Flood Control District. The Flood Control District is responsible for comprehensive and project planning for urban flood and runoff control to safeguard the public and property. The District was formed by the State legislature in 1969. Although responsible for flood control for urban runoff events, this District has been reluctant to assume responsibility for urban runoff water quality.

Presently, no single agency is responsible for regional planning for water supplies for Denver. However, the Denver Water Board presently supplies nearly two-thirds of the municipal raw water used in the region.

The Colorado State government also has an important role in planning and policy-making which directly effects the Denver region. The Regional Transportation District (RTD), which was formed by the State legislature, has the responsibility for improving bus service within the region and for developing a new fixed line transit system for metropolitan Denver. The State Division of Highways is responsible for many areas relating to transportation planning in Colorado and Denver, including road improvements and construction.

The Colorado Division of Planning serves as an advisory and coordinating agency. It was created within the Department of Local Affairs, to, among other things, prepare planning.

> "for meeting problems in areas of highways, air and water pollution, water supplies, sewage disposal, recreation, urban and non-urban growth, transportation, education, industrial and commercial development and related matters."

In addition, the Colorado Land Use Act established, within the Office of the Governor, the Colorado Land Use Commission in order to provide the leadership to encourage planned and orderly land use development. In a related matter, Governor Lamb issued a policy statement on growth in Colorado in 1976. Probably the most significant portion of this policy relevant to this EIS is that relating to future growth. Three most pertinent objectives are moderating net in-migration into the state, encouraging economic growth in areas other than the front range, and the minimizing of urban sprawl. Also, refer to Appendix A which contains the full text of this State policy statement.

Planning for air quality is the responsibility of the Air Pollution Control Commission and the Air Pollution Control Division (APCD) of the Colorado State Health Department. The APCD is in the process of developing an air quality maintenance plan for the Denver area. This work will be closely coordinated with other planning agencies through the policy bodies of these various agencies. Obviously, such cooperation is a necessary prerequisite for developing an implementable air quality maintenance plan since it requires assumptions as to future population, land use and transportation modes.

The State Water Quality Control Commission is the central authority in all matters pertaining to water pollution control in the State and the Denver region. The Commission sets water quality standards and classifies waters of the State for various beneficial uses. The Water Quality Control Division of the Department of Health is the administrative arm for water pollution control activities. Their principal responsibilities include: State water quality planning, administration of discharge permits, enforcement of water quality regulations, and review of applications and plans for new wastewater treatment plants.

III. Proposed Projects and Alternatives

SECTION III

THE PROPOSED PROJECTS AND ALTERNATIVES

PROPOSED PROJECTS

This section of the EIS presents proposed and alternative approaches that have been examined for meeting regional water quality goals.

BACKGROUND

This draft EIS has been prepared simultaneously with the draft Clean Water Plan prepared under Section 208 of the Water Pollution Control Act Amendments of 1972 (P.L. 92-500). The draft Clean Water Plan is commonly referred to as the 208 plan, and was prepared by the Denver Regional Council of Governments, the region's 208 planing agency. The Clean Water Plan is concerned primarily with non-point sources of water pollution, and secondarily with point sources. The draft Clean Water Plan and supporting draft Summary Technical Report are reproduced in the Appendix to this draft EIS. Plans for controlling point sources of pollution from the region's municipal wastewater treatment plants are called Facility Plans or 201 Plans, and are prepared under Section 201 of the Water Pollution Control Act Amendments of 1972.

The major non-point source of pollution in the Denver area is urban runoff. The 208 study has identified the effect of urban runoff for each of the fifteen subbasins on in-stream water quality. The conclusion reached by the Clean Water Plan is that, even with adequate point source controls, non-point sources in the form of urban/agricultural runoff would probably prevent year around achievement of desired water quality for all of the streams in the metropolitan area, except for the South Platte above Chatfield Dam. A detailed analysis was not undertaken for the Eastern Plains subbasin by the 208 study. As a result of this conclusion, the 208 study investigated the feasibility of implementing structural and non-structural control measures which would yield the desired water quality, stream segment by stream segment throughout the urban study area.

The major point sources of water pollution in the Denver region are effluent flows from regional and subregional wastewater treatment plants. Two basic approaches are being considered for control of these sources. One approach would transport wastewater to a large regional plant; the other would involve the operation of several subregional and local satellite plants. The latter approach is presently favored by DRCOG because of the greater opportunity for reuse of the region's wastewater and because it allows local control over water quality and allocation decisions. This preference is reflected in the point source recommendations of the 208 plan.

An issue that has not been resolved for point sources is whether to provide secondary treatment of wastewater, followed by land application, or to provide advanced treatment, including denitrification, with some form of effluent reuse. The selection of either of these options will depend on costs, local availability of land, water rights, public opinion, and local water demand. Both options, however, are predicated on the analysis that some form of advanced wastewater treatment will be needed in order to meet existing and/or future water quality goals.

Alternative and Preferred Non-Point Source Control Strategies

Basically, non-point sources consist of urban and rural stormwater runoff. The 208 Plan has estimated that non-point source control, which would result in the achievement of the 1983 goals, would cost the area approximately 255 million dollars per year amortized over the 20-year planning period. The conclusion of the 208 study is that this cost is excessive for the "minor" improvement in water quality that would be expected.

Of the 255 million dollars for non-point source controls, about 87% would be for structural controls which are designed to collect, store, treat, and discharge the treated stormwater. Therefore, a non-structural "program" approach to controlling non-point sources is being recommended by the 208 Clean Water Program. The goals of this approach would be to maintain and improve the quality of runoff in the region by, for example, such typical measures as improved street sweeping services, regulation of domesticated animal wastes, and regulation of lawn fertilizing. As part of this approach, the 208 Plan recommends that implementation of structural non-point controls be held in abeyance until specific problems can be pinpointed. The 208 plan suggests that more monitoring of stream water quality is needed to make this assessment and that such a program should be completed in several years.

Alternative and Preferred Wastewater Treatment Facility Designs

The following sections summarize the major known features of the individual facilities being collectively examined in this draft EIS. The description of each facility also includes a discussion summarizing the feasible alternatives from which the preferred design was selected and stating the reasons why it was considered superior.

Planning areas for these facilities are shown on Map J. Table III-A lists the facilities, their design flows, efflutent standards, and describes the feasible alternatives based on best available information.

South Adams County Water and Sanitation District Service Area--

The South Adams County Water and Sanitation District (SACWSD) encompasses about 10,000 acres of South Adams County and currently operates as an independent district. The present facilities consist of a 2.5-mgd (million gallons per day) plant using primary sedimentation, followed by trickling filters. The sludge is anerobically digested, dewatered on drying beds, and disposed of on land. The plant needs expanding and upgrading if it is to meet future effluent standards and to handle the service area's projected flow.

Two basic alternatives were considered. One was abandonment of the present plant, pumping all wastewater to the Metropolitan Denver Sewage Disposal District plant #1 (MDSDD #1). The other was expansion and upgrading of the current plant to handle future flows. The latter course was chosen (alternative 4), with phased construction of a 1.25-mgd expansion in 1978, addition of a 2.5-mgd ammonia removal step in 1983, and a 1.25-mgd increase in capacity, including ammonia removal, in 1986. This will provide a total plant capacity of 5.0 mgd by 1986. This plan is considered by the facility planner to be the most cost-effective and energy-efficient. The plant effluent would be discharged into the South Platte River.

Englewood/Littleton Advanced Wastewater Treatment Plant--

The cities of Littleton and Englewood have entered into a joint contract to build a treatment plant to handle the sewage from both cities. The new plant, now under construction, with a capacity of 20 mgd is located adjacent ot the present Englewood sewage treatment plant. Ultimate expansion to 38 mgd is planned in 1985. The City of Littleton is constructing a sanitary interceptor to carry excess waste from its treatment plant to the existing Englewood plant. The two existing treatment plants will not be expanded, and all future flows in excess of the capacities of the existing plants will be diverted to the joint-use plant. In the future, one or both of the existing plants may be phased out of service.

Currently a 201 facilities plan is being prepared for advanced treatment at the joint plant now under construction. The plan will consider ammonia and chlorine removal by various techniques, and effects of not adding these facilities. The plan will also consider whether to upgrade (but not expand) one or both of the existing plants or whether to phase them out. In considering the various

Table III-A. CURRENT FACILITY PLAN ALTERNATIVES
(* indicates plan recommendation)

Facility	Design flow, mgd	Effluent Standard	Alternatives Considered				
South Adams plant expansion and interceptor sewers	5.0	BOD: 20 mg/l SS: 20 mg/l NH_3-N: 3.5 mg/l fecal coliform: 200/100 ml residual Cl: 0.5 mg/l	Alt. 1: regionalization with Denver Metro (MDSDD #1 by 1983; 1.25-mgd activated sludge plant in 1977; abandoned by 1985. present worth: $6.7 million	Alt. 2: primary sedimentation, existing trickling filters (2.5 mgd); 1978, add 1.25 mgd activated sludge, 5.0 mgd dispersed floc nitrification; 1986, 1.25 mgd activated sludge sludge drying beds; disposed to land. present worth: $5.65 million	Alt. 3: primary sedimentation, existing trickling filters (2.5 mgd); 1978, add 1.25 mgd rot. biol. disc (RBD) with nitrification; 1983, 2.5 mgd RBD nitrification; 1986, 1.25 mgd RBD with nitrification; sludge anaerobically digested, drying beds, disposed to land. present worth: $6.2 million	Alt. 4:* primary sedimentation, existing trickling filters (2.5 mgd); 1978, add 1.25 mgd RBD without nitrification; 1983, 2.5 mgd RBD nitrification; 1986, 1.25 mgd RBD with nitrification; sludge anaerobically digested, drying beds, disposed to land. present worth: $6.15 million	
Englewood/ Littleton advanced wastewater treatment plant	20		Alt. 1: Chlorine and ammonia removal facilities at Littleton plant, the Englewood plant and the L/E plant. Littleton plant and Englewood plant to receive a base-load flow and all excess to the L/E plant. ann. cost: $636,000	Alt. 2: Chlorine and ammonia removal facilities at the L/E plant and the Littleton plant. Phase out the Englewood plant. The Littleton plant to receive a base-load flow and all excess flows to the L/E plant. ann. cost: $718,000	Alt. 3: Chlorine and ammonia removal facilities at the L/E and the Englewood plants. Phase-out the Littleton plant. The Englewood plant to receive a base-load flow and all excess flows to the L/E plant. ann. cost: $649,000	Alt. 4: Chlorine and ammonia removal facilities at the L/E plant only. Phase-out the Littleton plant and the Englewood plant. ann. cost.: $680,000	Alt. 5: Considerations and probable effects to stream reclassification to eliminate the need for any chlorine and/or ammonia reduction facilities. ann. cost.: $630,000
South Lakewood plant expansion vs. interceptor to Denver*	present population: 68,000 maximum population: 80,000 to 85,000		Alt. 1: improve and/or enlarge existing treatment plant to serve only South Lakewood, Bonvue, Daniels and part of Lakewood; parallel some outfall sewers within these districts. (Existing plant size: 2.0 to 3.0 mgd).	Alt. 2: make no improvements to existing plant, but transport effluent to MDSDD #1, for further treatment.	Alt. 3: abandon existing plant; lay larger trunk sewer to connect to Metro District interceptor line (i.e., all flows to MDSDD #1 for treatment).	Alt. 4: Enlarge existing plant, construct AWT and improved sludge handling facilities; consider construction of lines for recycling effluent for urban irrigation. (Plant site 5 - 6 mgd).	

Table III-A (Continued). CURRENT FACILITY PLAN ALTERNATIVES

Facility	Design flow, mgd	Effluent standard	Alternatives Considered			
Cherry Creek and Goldsmith Gulch interceptor sewer	185		Alt. 2: system of sewers to carry entire area flow to Northside plant; upper half parallels eastern bank of S. Platte River, lower half parallels existing Delgany main; no pumping station required.	Alt. 3: same as Alt. 2, except sewers routed to east of downtown area rather than parallel to Cherry Creek outfall and eastern bank of S. Platte River.	Alt. 4: same as Alt. 2, except flow routed directly to MDSDD #1 instead of Northside via Sand Creek.	Alt. 5[a]: same as Alt. 2, except capacity based only on 1985 projected flow (136 mgd); additional future capacity provided by construction of Cherry Creek satellite plant and staged expansion of plant as required; plant effluent to be reused; 1985 design: 8 mgd.
			present worth: $25.2 million	present worth: $26.2 million	present worth: $28.5 million	present worth: $25.9 million
Lower South Platte treatment plant and interceptor sewers	26 (including 6.0 SACWSD)	BOD: 20 mg/l SS: 20 mg/l NH_3-N: 3.0 mg/l DO: 5 mg/l Color: 25 JTU: 25 fecal coliform: 1,000/100 ml residual Cl: 0.05 mg/l	Alt. 4[a]: new plant at 164th Ave. and S. Platte River to treat flow from Brighton, Lower Thornton and 1st, 2nd and 3rd creeks; flow from Upper Thornton and NWSWSD pumped to MDSDD #1 (1981 plant: 8.3 mgd, 1990 to MDSDD #1: 8.3 mgd, 2000 to SACWSD; 6 mgd); SACWSD to remain independent; effluent discharged.	Alt. 5: same as Alt. 4, except flow from Lower Thornton also pumped to MDSDD #1 (1981 plant: 3.7 mgd, 1990 to MDSDD #1: 13.3 mgd); effluent discharged.	Alt. 14: same as Alt. 5, except flow from Lower Thornton pumped to Big Dry Creek Treatment Plant (City of Westminster); effluent discharged.	
			present worth: $25.1 million	present worth: $25.2 million	present worth: $24.4 million	

Table III-A (Continued). CURRENT FACILITY PLAN ALTERNATIVES

Facility	Design flow, mgd	Effluent standard	Alternatives Considered		
				Clear Creek	
Clear Creek and Sand Creek service areas	~35	BOD: 20 mg/1 SS: 20 mg/1 NH_3-N: 3.0 mg/1 DO: 5.0 mg/1 Color: 25 JTU: 25 fecal coliform: 1,000/100 ml residual Cl: 0.05 mg/1	Alt. 1† parallel Clear Creek interceptor to transport all basin flow to MDSDD #1 for treatment.	Alt. 8a: new plant near Youngfield St. and 40th Ave. to provide treatment through NH_3-N removal for flows from N. Table Mountain, Applewood and Pleasant View (air activated sludge; sludge anaerobically digested; drying bed; sold); 1983: 6.56 mgd; effluent for urban reuse; remainder transported to MDSDD #1 for treatment.	Alt. 10: same as Alt. 8a, except flows from Golden, Northwest Lakewood and Westridge also treated at new plant (1983: 13 mgd); effluent for urban reuse; remainder transported to MDSDD #1 for treatment. Note: Golden has proposed its flows be treated locally, by a new plant, for reuse.
			present worth: $22.2 million	present worth: $28.4 million	present worth: $30.8 million
				Sand Creek	
	30–40	BOD: 20 mg/1 SS: 20 mg/1 NH_3-N: 3.0 mg/1 DO: 5.0 mg/1 Color: 25 JTU: 25 fecal coliform: 1,000/100 ml residual Cl: 0.005 mg/1	Alt. 1: parallel Sand Creek interceptor to transport flow from entire basin to MDSDD #1.	Alt. 3† new plant at existing Aurora plant site for primary through advanced treatment for established flow volumes (air activated sludge; sludge anaerobically digested; drying bed; marketed); effluent for urban, domestic, agricultural or industrial reuse, preferably domestic reuse in Quincy reservoir; remainder of flow to MDSDD #1 for treatment.	Alt. 4: same as Alt. 3, except all flow from Sand Creek interceptor treated at new plant; remainder of flow to MDSDD #1 for treatment.
			present worth: $18.7 to 22.0 million	present worth $19.8 to 21.5 million	present worth: $22.7 to 25.4 million

Table III-A (Continued). CURRENT FACILITY PLAN ALTERNATIVES

Facility	Design flow, mgd	Effluent standard	Alternatives Considered			
Broomfield/ Westminster regional treatment plant	10	BOD: 20 mg/1 SS: 20 mg/1 NH_3-N: 2.5 mg/1 DO: 6.7 mg/1 JTU: 50 Color: 60 fecal coliform: 200/100 ml residual Cl: 0.5 mg/1	Primary alternative 1. conventional primary settling 2. vertical screening.	Secondary alternative 1. air activated sludge 2. oxygen activated sludge 3. activated biological filter 4. rotating biological disc clarification in circular clarifiers and chlorine disinfection	Solids handling 1. pump liquid sludge to MDSDD #1 for treatment 2. treat at site: a. digestion: air aerobic, oxygen aerobic, anaerobic b. dewatering: drying beds, heat and vacuum filter, vacuum filter, filter press, centrifuge c. disposal: landfill, incineration	This recommendation was made by a Facilities Plan completed two years ago. Recommendation was rejected; Plan is being redone.
Metro Denver Sewage Disposal District Plant # 1	185		Alt.: 1 Treatment and discharge consideration will be given to various methods and levels of ammonia removal Discharge to the South Platte River.	Alt. 2: Land Application consideration will be given to irrigation, high-rate irrigation, overland flow, and infiltration/percolation.	Alt. 3: Treatment & reuse consideration of domestic reuse by the Denver Water Board and successive use for irrigation via Burlington Dithc. These evaluations will also involve all pertinent water rights issues.	

[a] Plan of study only; recommended alternative not determined; costs not determined; standards, flow rates not given.

NOTE: The symbol * indicates the recommended alternative.

alternatives, the degree of treatment required to meet all projected flows and effluent limitations will be assessed.

South Lakewood Service Area--

The Lakewood service area encompasses approximately 11,300 acres. The area is extensively developed, having a present population of about 68,000 and a maximum projected population of 80,000 to 85,000. The existing treatment plant is operated by the South Lakewood Sanitation District and currently serves about 37 percent of the existing population, or 25,000 people. The remainder of the area flow is transported to and treated by the MDSDD #1 plant.

The facility plan for the area is still in preparation, but the plan of study has indicated the following alternatives for meeting future effluent requirements: (1) improve and enlarge the existing plant to treat flows from the areas currently served, the rest continuing to go to MDSDD #1 for treatment; (2) continue to use the existing plant, but transport the effluent to MDSDD #1 for further treatment; (3) abandon the existing plant, and transport all flows to MDSDD #1; and (4) enlarge the existing plant, add advanced treatment and sludge disposal facilities, and either discharge to the South Platte River through the existing outfall line or use the plant effluent for irrigation purposes on City lands. Alternative 4 is presently expected to be recommended.

Cherry Creek and Goldsmith Gulch Service Area--

Improvements to the wastewater collection system for the upper Cherry Creek service area are being planned and should be considered in conjunction with the proposed improvements to the Northside Treatment Plant. This area is within the jurisdiction of MDSDD #1.

Alternatives in the Cherry Creek and Goldsmith Gulch facility plan considered both the transport of all area flows to the Denver Northside/MDSDD #1 treatment complex and the transport of some waste to the Northside complex, with the remainder of the waste going to a satellite advanced wastewater treatment (AWT) plant to be constructed in 1985. (Wastewater from the AWT plant would be reclaimed through domestic, agricultural, or industrial use, whichever is most feasible at the time.) The latter alternative has been selected, alternative 5, with the option of building the satellite plant in 1985 only if it is deemed feasible at the time. In lieu of a satellite plant, additional sewers could be constructed to the Northside plant. The plan provides maximum flexibility, requires the lowest initial capital investment, provides for wastewater reuse, reduces future flow to the Northside/MDSDD #1 complex, and provides a shorter distance for wastewater to travel. The satellite plant would consist of a secondary treatment, followed by tertiary treatment which would be applied only when effluent is discharged into Cherry Creek. Domestic reuse, industrial reuse, and irrigation were suggested as possible options.

Lower South Platte Service Area--

The lower South Platte basin occupies the western part of Adams County and lies generally northeast of metropolitan Denver. It is divided into nine subareas. The service area is administered by the Metropolitan Denver Sewage Disposal District No. 1.

The facility plan originally considered 14 alternatives but narrowed these down to three for final consideration. All three call for a new wastewater treatment plant to be built at 164th Avenue and the South Platte River, and for the South Adams plant to be expanded and to continue operating as a separate district. The major differences in the three plans concern the amount of the area's waste to be treated at the new plant, how much is to be pumped to MDSDD #1, and whether or not any waste can be pumped to the City of Westminister's treatment plant in the Big Dry Creek Basin for treatment and agricultural use. The selected plan, alternative 4, provides for treating the greater portion of the area's waste by the new plant, with the option left open to pump some flow to the Westminster plant. It was assumed for comparison purposes that the treatment plant would provide secondary treatment, with ammonia removal, sludge handling by anaerobic digestion, air drying, and subsequent marketing. Agricultural use was not considered seriously because of its projected cost.

Clear Creek and Sand Creek Service Areas--

The Sand Creek Basin encompasses a large portion of Arapahoe County, smaller portions of Adams County, and the City and County of Denver. It is divided in five subbasins, administered by MDSDD #1.

The facility plan focused on basically two alternatives: Alternative 1 involves transport of all area wastewater flow to MDSDD #1 for treatment; Alternatives 3 and 4 involve advanced treatment of varying quantities of flow by a new plant and reuse of the water for domestic purposes. Since a large portion of the water currently received by the City of Aurora is "new" western-slope water, a portion of this water can be reused by the City before discharge. This water would be treated and pumped to the Quincy reservoir, a domestic raw water supply.

Alternative 3 was selected as the preferred alternative. This plan provides advanced treatment and reuse of a smaller portion of wastewater than under Alternative 4, but it is significantly less expensive. It has several advantages over Alternative 1, providing for reuse and successive use of water, reducing the amount of sewer construction along Sand Creek, and maximizing the use of existing facilities. For purposes of comparison, the new treatment plant was assumed to provide secondary treatment with ammonia removal, sludge handling by anaerobic digestion, air drying, and subsequent marketing.

The Clear Creek planning area, which occupies portions of Jefferson and Adams counties, lies generally northwest of metropolitan Denver and includes 11 subbasins. It is administered by the MDSDD # 1. The facility plan evaluated seriously two alternatives, one involving transport of all area wastes to MDSDD #1, the other involving treatment through ammonia removal of some of the area flow. On the primary basis of cost, Alternative 1, the transport of all area wastes to MDSDD #1, was selected.

Broomfield/Westminster Service Area--

This service area encompasses the cities of Broomfield, Westminster, and portions of Thornton. The City of Northglenn is not included as it has selected an independent course of action. Existing facilities include a 3.6-mgd plant operated by the City of Broomfield and a 1-mgd plant operated by the City of Westminster. Both plants discharge into Big Dry Creek. The facility plan recommendation shown in Table III-A was rejected and a new plan is in preparation.

The Westminster plant is currently operating at or near capacity, and immediate expansion to 2 mgd is planned, to prevent the imminent pollution of Big Dry Creek. A new 201 facility plan is being prepared, to consider further expansion of the plant to approximately 4.5 to 6.0 mgd. This would provide adequate capacity to treat flows from Broomfield in excess of 3.6 mgd as well as all other area flows.

In an effort to thwart the efforts of adjacent cities to condemn agricultural water for municipal purposes and to show that cooperation is superior to condemnation, the Northglenn City Council entered into an agreement in 1976 with the Farmers Reservoir and Irrigation Company Board of Directors which allows Northglenn to borrow water from Standley Lake, use it for municipal purposes, collect the sewage, treat the sewage, and store the winter flows for summer irrigation by farmers. Urban drainage, lawn irrigation return flow, deep well water and South Platte alluvial well water will also be collected, treated if required, and transported to a storage facility in such quantities as to return all of the borrowed water to the farmers plus provide a 10 percent "bonus".

Subsequently, a contract was signed in 1977 between the City of Westminster and the Farmer's High Line Canal Company for an exchange of water rights. Under this agreement, secondarily treated effluent will be discharged to the canal and used for irrigation of crops, and an equivalent amount of raw water will be diverted from the canal to Standley Lake, which is the city's municipal water supply (Reference 972).

Expansion of Metropolitan Denver Sewage Disposal District Plant No. 1--

Currently, expansion of MDSDD #1 to include additional secondary treatment is being completed, which will increase the treatment capacity to 170 mgd. Ammonia removal facilities will have to be added to this plant by 1983 in order to meet effluent standards at that time. The addition of ammonia removal capability should increase the plant capacity to approximately 190 mgd, and phased additions will provide a capacity of 205 to 220 mgd by the year 2000.

The facility plan for additional treatment has not yet been prepared; however, the plan will consider three basic alternatives: treatment and discharge to the South Platte River, land application of effluent, and treatment and reuse. Under the treatment and discharge alternative, various methods of ammonia removal will be considered. Under the land application alternative, methods to be considered will include irrigation, high-rate irrigation, overland flow, and infiltration/percolation. Under the treatment and reuse alternative, consideration should be given to domestic reuse by the Denver Water Board and to successive use for irrigation via Burlington Ditch, including considerations of water rights issues. The course likely to be followed is the treatment and discharge alternative as it will involve the fewest legal and technical problems and will, in all probability, be relatively less costly compared to the other alternatives.

208's Recommended Plan for Municipal Wastewater Treatment Plants

Table III-B identifies the costs and effluent levels for the major facilities in the Denver metropolitan area, as estimated by the DRCOG 208 program. The costs are total capital and operation and maintenance costs for all aspects of municipal wastewater control through the year 2000.

Table III-B

Recommended Plan for Municipal Wastewater Treatment Plants

Facility	Cost[1] (Millions)	Effluent Requirement (mg/1)			
		BOD	NH_3-N	NO_3-N[4]	PO_4-P
Littleton/Englewood	48.1	5	1	1	8
South Lakewood	6.8	5	1	1	8
MDSDD#1	97.1	20	18	-	8
South Adams County	7.5	20	18	-	8
Brighton	4.1	20	18	-	8
Glendale	1.8	5	1	1	8
Sand Creek	16.0	20	18	-	8
Golden	9.9	5	1	1	0.3
Big Dry Creek	15.3	5	0-3[2]	15	8
Louisville	4.2	5	1	1	8
Lafayette	6.9	5	1	1	8
Erie	2.6	5	1	1	8
Boulder	24.2	5	1	1	8
Longmont	6.2	20	18	-	8
Mountains	5.0	20	9/15[3]	-	8
Plains	1.3	20	15	-	8

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[1] These present worth costs reflect capital for facilities and interceptors and operation and maintenance of the facilities, interceptors, and collection systems through the year 2000.

[2] Full-time nitrification with part-time breakpoint chlorination for total ammonia removal.

[3] Bear Creek requires nitrification to 9 mg/1 of NH_3-N, but all other mountain and plains areas are 15 mg/1 NH_3-N as given in the Mountain and Eastern Plains Water Quality Study.

[4] Dash indicates that nitrate will not be a problem unless discharges are excessive.

Source: "Technical Report Summary" DRCOG March 1977

The effluent levels describe what can be reasonably expected for each community's discharge after proper treatment to achieve compliance with the 208's proposed stream classifications and criteria. These limitations do not reflect the minimum requirements for each parameter which would eventually be the basis for issuing NPDES discharge permits. For example, the 5 mg/l of BOD specified for Boulder is the level one would expect in their effluent after meeting phosphate and nitrate requirements.

EIS ALTERNATIVES - POINT SOURCES

In keeping with the regional overview of this draft EIS, three basic strategies were assembled from the various alternatives examined in completed and ongoing facility planning efforts. One of these strategies, no-action, is required by the National Environmental Policy Act. Each of these alternative strategies will be assessed in subsequent sections of this report for their environmental impacts. Mitigating measures to reduce or eliminate impacts will also be evaluated. It is expected that the information in this draft EIS, plus public review and input, will change and evolve one of the strategies into a course of action which will minimize environmental impacts and maximize environmental benefits. The three basic facility plan strategies addressed in this draft EIS are termed LOCAL, REGIONAL, and NO ACTION. They are summarized in Table III-C.

The Local Alternative

This alternative generally consists of the recommended alternatives of the completed Facility Plans, and the alternatives examining expansion and/or upgrading of treatment levels for existing wastewater treatment plants for facility plans now in progress. The exception is that the recommended alternative for the Clear Creek service area, parallel interceptor to MDSDD #1 plant, is replaced by the alternative (8a) calling for a new plant serving North Table Mountain, Applewood, and Pleasant View with the remainder served by interceptors to the MDSDD #1 plant. Alternative 4 of the ongoing South Lakewood facility planning effort is assumed for the local Alternative. Figure III-A illustrates this alternative. This alternative close resembles the recommendations of the Clean Water Plan (208 Plan).

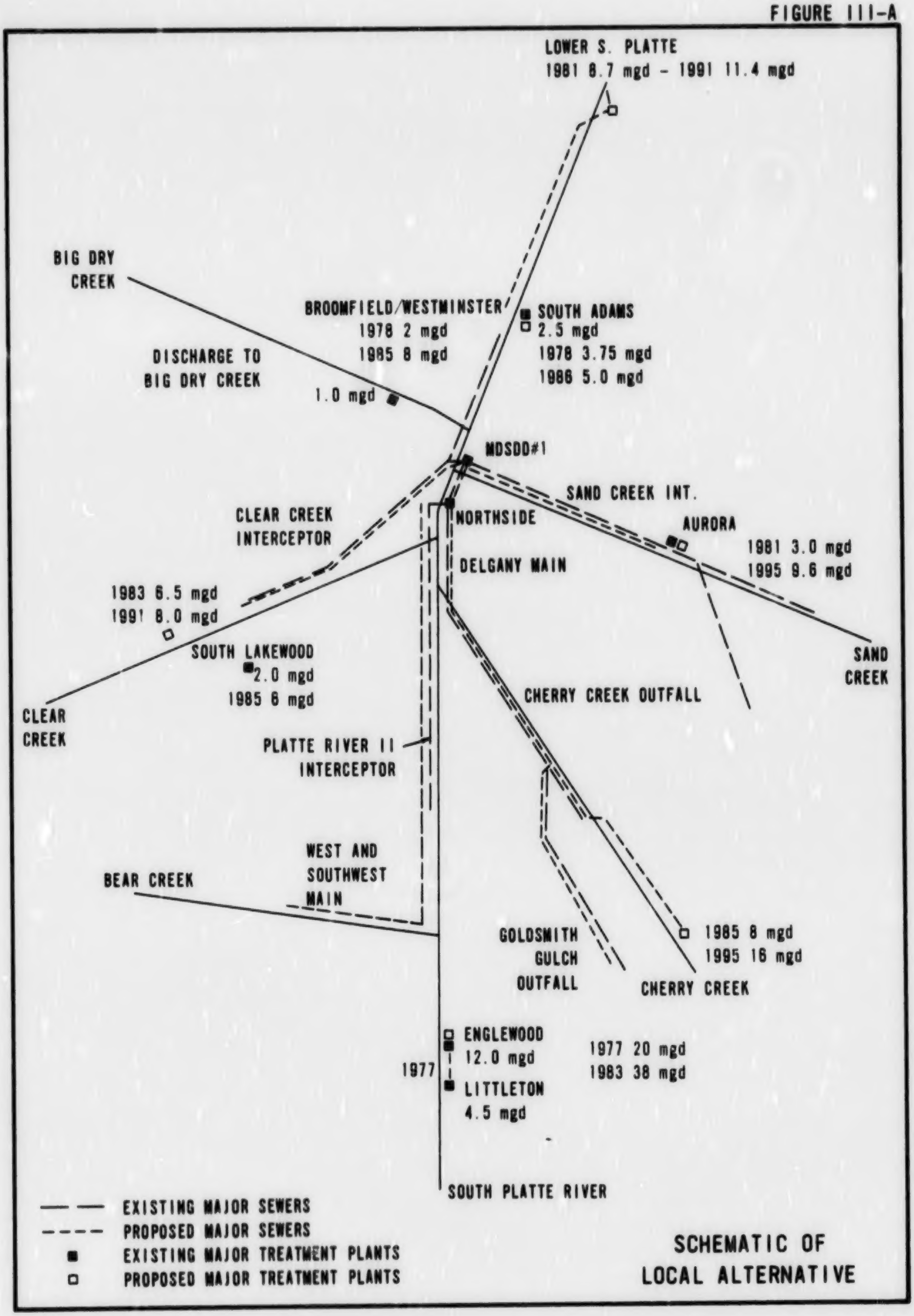
The Regional Alternative

This alternative generally consists of alternatives examined in the completed and in-progress Facility Plans which call for centralized treatment at the Northside/MDSDD #1 treatment complex. Figure III-B illustrates this alternative.

Table III- C. SUMMARY OF ALTERNATIVES

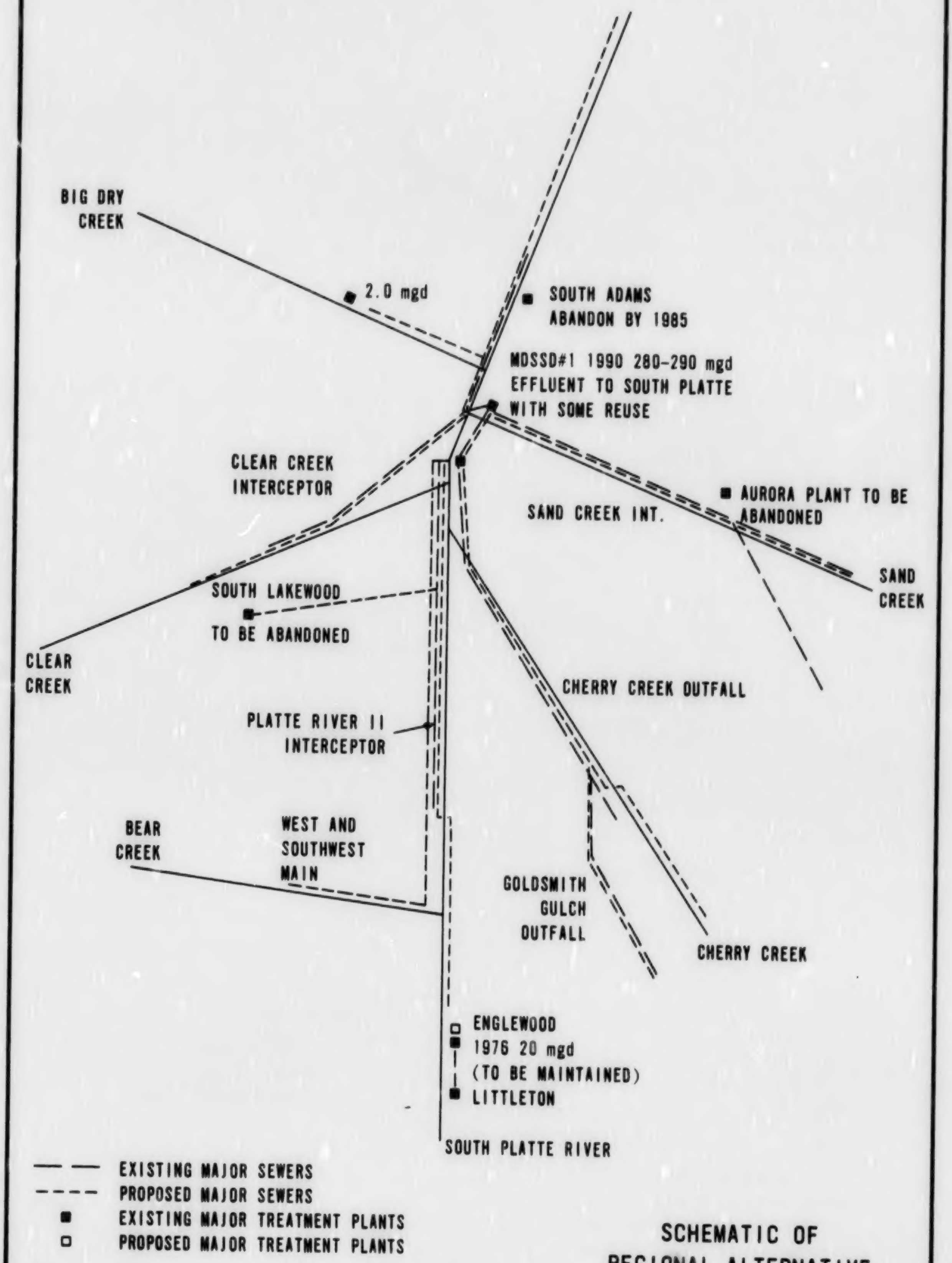
Service area	Local alternative	Regional alternative	No-action alternative
South Adams	Maintain existing plant, add 1.25 mgd without nitrification 1978, 2.5 mgd nitrification in 1983, and final 1.25 capacity addition with nitrification in 1986 for a total capacity of 5 mgd	Add 1.25 mgd activated sludge capacity in 1977, abandon plant in 1985, all flows to MDSDD #1	Add 1.25 mgd activated sludge and 5 mgd dispersed floc nitrification capacity 1978, final 1.25 mgd activated sludge added in 1986
Englewood/Littleton	Addition of ammonia and chlorine removal for 20 mgd capacity by 1979. Further expansion of joint plant to total capacity with AWT to 38 mgd in 1983	Same as local alternative except flows over 20 mgd transported to MDSSD #1	Addition of ammonia and chlorine removal delayed till 1980. Ultimate expansion to 38 mgd delayed to 1986.
South Lakewood	Enlarge existing plant, construct AWT and improved sludge handling facilities; capacity expanded from 2 mgd to 5-6 mgd. Some effluent reuse	Abandon existing plant and transport all flows to Northside/MDSSD #1 complex	Maintain existing plant, and service area, transport effluent to Northside/MDSDD #1 complex
Cherry Creek/ Goldsmith Gulch	System of interceptors to expected 1985 flow from upper Cherry Creek to Northside/MDSDD #1 complex. Provision for AWT satellite plant in 1985	Same as local alternative except additional interceptors added in 1985 in lieu of AWT Cherry Creek satellite plant	Same as local alternative except construction of interceptors delayed two years, plans for satellite plant abandoned
Lower South Platte	New plant for flows from Brighton, lower Thornton, 1st, 2nd and 3rd creeks. Remainder of area flows to MDSDD #1 and South Adams County Water and Sanitary District.	All flows transported to MDSDD #1	Same as local alternative except delayed four years.
Clear/Sand creeks	New plant with 6.5 mgd capacity in 1983 on Clear Creek. AWT for reuse. Additional flows to MDSDD #1	Parallel Clear Creek interceptor to transport all basin flow to MDSDD #1 for treatment.	Same as regional alternative except delayed three years
	New plant at existing Aurora plant site for 30-40 mgd with reuse. Remainder of flows to MDSDD #1	Parallel Sand Creek interceptor to transport flow from entire basin to MDSDD #1. Abandon existing Aurora plant	Same as regional alternative except delayed three years
Bloomfield/ Westminster	Expansion of existing Big Dry Creek plant to 8 mgd by 1985 with land application/agriculture reuse.	Maintain existing plants with excess flow to MDSDD #1	Expansion of existing Big Dry Creek plant to 5 mgd, expansion of Bloomfield plant by 3 mgd, lower Thornton to MDSDD #1
MDSDD #1	Addition of ammonia removal for total plant capacity of 190 mgd by 1983. Optim for reuse	Plant expansion with ammonia removal for total capacity by 1990 of 260-270 mgd.	Addition of ammonia removal facilities delayed until 1985

FIGURE III-A


LOWER S. PLATTE
1981 8.7 mgd - 1991 11.4 mgd
BIG DRY CREEK
BROOMFIELD/WESTMINSTER
1978 2 mgd
1985 8 mgd
SOUTH ADAMS
2.5 mgd
1978 3.75 mgd
1986 5.0 mgd
DISCHARGE TO BIG DRY CREEK
1.0 mgd
MDSDD#1
SAND CREEK INT.
CLEAR CREEK INTERCEPTOR
NORTHSIDE
AURORA
1981 3.0 mgd
1995 9.6 mgd
DELGANY MAIN
1983 6.5 mgd
1991 8.0 mgd
SOUTH LAKEWOOD
2.0 mgd
1985 6 mgd
SAND CREEK
CHERRY CREEK OUTFALL
CLEAR CREEK
PLATTE RIVER II INTERCEPTOR
WEST AND SOUTHWEST MAIN
BEAR CREEK
GOLDSMITH GULCH OUTFALL
1985 8 mgd
1995 16 mgd
CHERRY CREEK
ENGLEWOOD
12.0 mgd
1977
LITTLETON
4.5 mgd
1977 20 mgd
1983 38 mgd
SOUTH PLATTE RIVER
— — EXISTING MAJOR SEWERS
- - - - PROPOSED MAJOR SEWERS
■ EXISTING MAJOR TREATMENT PLANTS
□ PROPOSED MAJOR TREATMENT PLANTS

SCHEMATIC OF LOCAL ALTERNATIVE

FIGURE III-B


BIG DRY CREEK
2.0 mgd
SOUTH ADAMS ABANDON BY 1985
MDSSD#1 1990 280-290 mgd EFFLUENT TO SOUTH PLATTE WITH SOME REUSE
CLEAR CREEK INTERCEPTOR
SAND CREEK INT.
AURORA PLANT TO BE ABANDONED
SAND CREEK
SOUTH LAKEWOOD TO BE ABANDONED
CLEAR CREEK
CHERRY CREEK OUTFALL
PLATTE RIVER II INTERCEPTOR
BEAR CREEK
WEST AND SOUTHWEST MAIN
GOLDSMITH GULCH OUTFALL
CHERRY CREEK
ENGLEWOOD 1976 20 mgd (TO BE MAINTAINED)
LITTLETON
SOUTH PLATTE RIVER
— — EXISTING MAJOR SEWERS
- - - PROPOSED MAJOR SEWERS
■ EXISTING MAJOR TREATMENT PLANTS
□ PROPOSED MAJOR TREATMENT PLANTS

SCHEMATIC OF REGIONAL ALTERNATIVE

The No-Action Alternative

This alternative assumes that no EPA grant funds for design and construction would be received by local agencies. As water quality standards would still have to be met, this alternative assumes that wastewater treatment facilities would still have to be constructed. Financing would be borne entirely by local agencies, primarily the City and County of Denver and MDSDD #1, probably by revenue bonds retired by user charges and connection fees. Some costs may be met through other revenue sources.

ALTERNATIVES TO STREAM DISCHARGE

Land application of wastewater effluent*may be used with existing irrigation or by development of new irrigation on cropland, rangeland,or forested areas and parks. In general two basic approaches are involved: ownership and operation of a land treatment system, or distribution of effluent to an existing agricultural or other operation. The latter system is a more realistic possibility for the eastern Colorado area. Excessive costs, water rights problems, and the complications of entering the agricultural market have made wastewater treatment agencies reluctant to enter the land application field.

Systems involving reuse are being looked upon with increasing favor by Colorado communities. Some communities view wastewater reuse as a potential means of increasing their domestic water supplies, and/or as a means of avoiding the condemnation of agricultural water rights. Generally only those communities owning non-tributary (West Slope diversion) water are legally entitled to "reuse" water for their own purposes. Other potential systems however have the capability of increasing water supplies for municipalities using South Platte tributary water.

EPA's chief concern is, of course, protection and enhancement of water quality. If any of the potential reuse or land application systems have positive water quality benefits that would result in attainment of relevant stream standards, such systems may be eligible for construction grant funding.

There are a number of ways wastewater reuse systems could operate. Most reuse systems proposed or in operation use one or a combination of three basic approaches. These are:

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* Effluent is the term used to describe the discharge of treated wastewater.

Direct Reuse--Where a municipality is discharging wastewater to a stream and a user downstream is diverting waters for agriculture from the stream, it is possible for the municipality to fulfill the agricultural users needs by direct discharge of wastewater effluent to an agricultural supply ditch. The raw water normally diverted for agricultural use could be left in stream. This fact and the removal of wastewater effluent nutrients from the stream could result in significant water quality advantages. This approach does not result in an increased municipal water supply, and could only be implemented with imported western slope water unless a water exchange agreement for South Platte water rights was in force. This is because rights to imported water include rights to reuse. South Platte water must be returned to the stream.

Water Exchange--Upstream agricultural rights to South Platte or tributary water may be exchanged for direct discharges to agricultural users holding upstream rights. In this way, agricultural users still receive the same quantity of water, it is just "used" before they get it. This approach can be used to increase municipal water supplies without condeming (seizing) agricultural water rights for municipal use.

Recycle--This system would involve having a municipality reuse its own treated wastewater effluent as part of its expanded potable water supply. Such a recycling system could substitute for water that would have to be developed from other sources for population growth; however, very high levels of treatment would be required.

Other potential reuse schemes could involve the use of treated wastewater for industry, urban irrigation, etc. These latter uses would be possible only if the water were non-tributary, since additional uses could consume some of the supply. These latter systems are subsets of the "recycling" system.

All of the potential reuse schemes discussed are under consideration in the metropolitan Denver area. The water exchange and reuse arrangements are currently used at times at the Metro plant with the adjacent Burlington Ditch, Westminster and Northglenn have proposed systems of the water-exchange type for increasing water supply type. Recycling is being seriously considered by the Denver Water Board and Aurora. Reuse by urban irrigation is now practiced by Aurora and South Lakewood, and Aurora is also considering the possibility of industrial reuse of effluent.

CLEAN WATER PLAN MANAGEMENT ALTERNATIVES

Section 208 of PL 92-500 requires that any plan prepared under its authority recommend management agencies which would be responsible for plan implementation. In response to this requirement DRCOG in its draft Clean Water Plan evaluated six water quality "management" alternatives for point sources. They are:

1. Continuation of the existing system.
2. Basin or service area approach.
3. Regional Service Authority.
4. Metropolitan Council.
5. State oriented approach.
6. Single-purpose agency approach.

For non-point sources, the 208 plan considered existing institutions only.

Point Sources

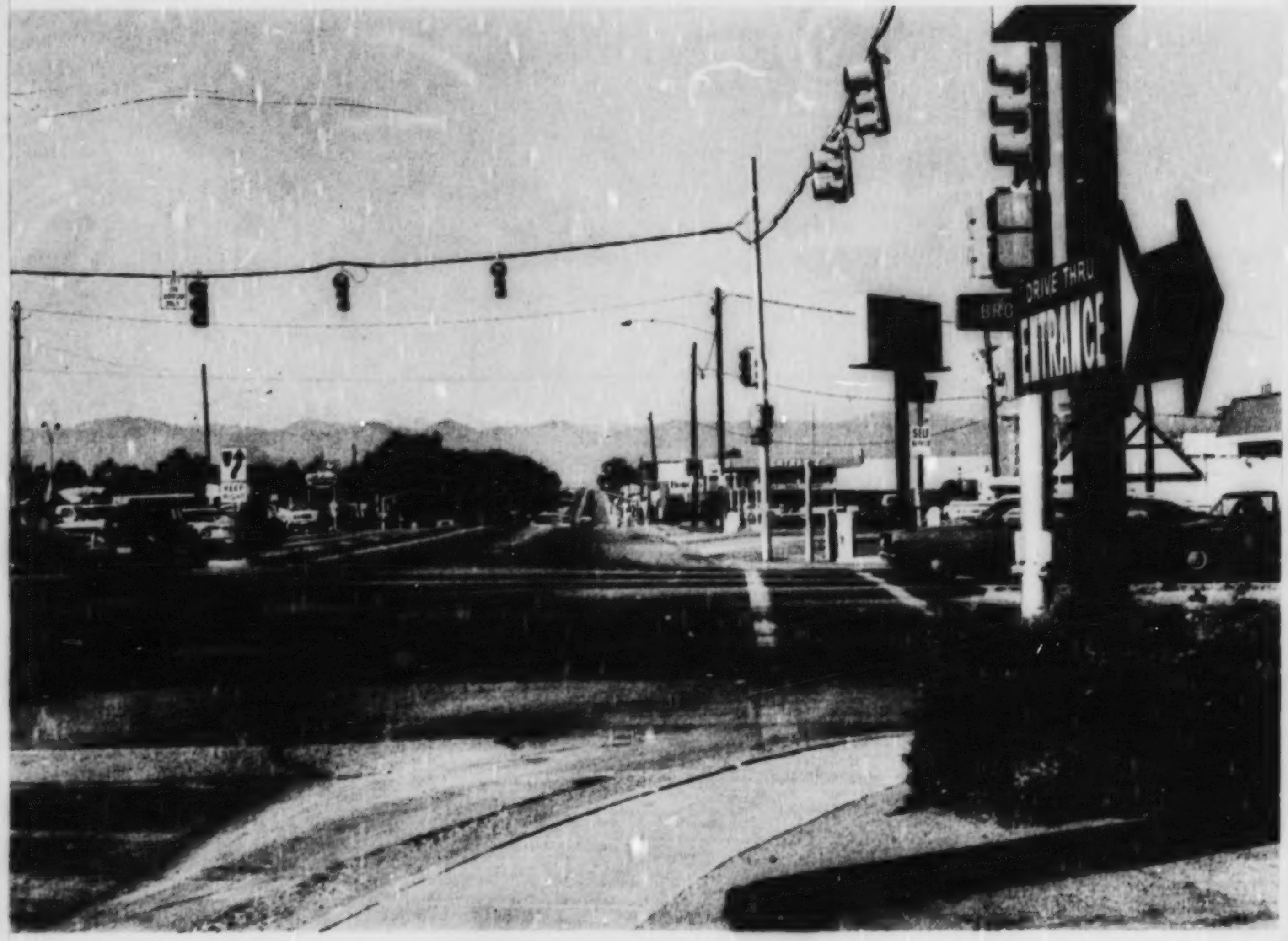
DRCOG is recommending for municipal point sources that all districts and municipal treatment agencies as of July 1, 1977, be designated management agencies. Exceptions to this are the cities of Longmont and Lyons, the Niwot Sanitation District which will be included within the St. Vrain-Left Hand Conservancy District,and the Highline Park and Water and Santitation District which will be represented by the Supervisory Group of the Littleton/Englewood Management agency. Single purpose collector agencies and treatment agencies with wastewater flows under 1 million gallons per day (mgd) are not being recommended for designation by the 208 plan.

The DRCOG is concerned that the 34 agencies proposed for designation, coordinate their future wastewater activities, Therefore, the 208 plan is recommending that a Water Quality Advisory Committee be formed with representatives from each management agency and six others representing two other existing DRCOG water related committees. The primary function of this coordinating group would be to set priorities for wastewater treatment projects within the 208 area.

The 208 study has identified short term and long term goals for future consolidation of these management agencies. The short term goals are: (1) to form immediately within each subbasin, a cooperative organization which consists of all the designated management agencies within that basin, and (2) at the end of five years after approval of the initial 208 plan, to have only one designated management agency per subbasin. The long term goal is to establish a form of metropolitan governance which has enforcement and veto power as well as responsibility for municipal wastewater management.

Non Point Sources

The 208 plan recommends that no agencies be designated, at this time, to have management responsibilities for the water quality aspects of non-point sources. This recommendation is based on the following factors: (1) non-point source problems were identified on a regional basis, but specific sources were not identified; (2) the logical agency for urban stormwater control, the Urban Drainage and Flood Control District (UD&FCD) does not have statutory authority for water quality; and (3), the UD&FCD was reluctant to assume responsibility for the water quality of urban runoff. DRCOG is suggesting that designation of nonpoint source management agencies be postponed pending further analysis of the specific nonpoint problems within the 208 study area.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ENTRANCE
BRO

IV. Probable Environmental Impacts

SECTION IV

PROBABLE ENVIRONMENTAL IMPACTS

The future of the Denver region will be shaped by the growth the region experiences in population, production of good and services, and supportive facilities. The expansion of wastewater collection and treatment capacity affects the amount and distribution of growth in a region by increasing the supply of developable land. Because growth may generate significant secondary impacts in terms of the natural and social environment, this chapter begins with an examination of the region's likely future growth as the basis for subsequent evaluation of probable environmental impacts of the 201 facilities plan, and the Clean Water Program.

SOCIO-ECONOMIC IMPACTS

Regional Population and Economic Impacts

Sources of regional growth--

The growth of a region starts with the creation of jobs serving markets outside of the region. Agriculture, manufacturing and military activity form part of Denver's export economy (basic demand). As people move into the region, jobs serving the local market are created in activities such as retail trade, entertainment and construction (local demand). The number and diversity of firms serving the local market grow with the increase in basic demand and in population. The purchase of locally produced goods and services leads to continued production using local labor, land and capital. This results in additional locally produced goods and services. The creation of jobs in basic demand sectors provides the base for population growth, but population growth provides the labor force to fill the jobs and creates additional jobs serving the local market. Thus, population growth and economic growth become interdependent.

The relationship between job growth and economic growth is subject to a number of influences. One of these is imperfect labor mobility. Inadequate information about changing economic conditions results in a lag in response which may differ among age and skill groups in the labor force: the more mobile, highly educated segments of the labor force respond to such information more rapidly, while in-migration of the less educated and/or less skilled may be slower to taper off. Some in-migration may occur even in the face of adverse local economic conditions because the newcomer may be coming from a location where economic conditions are even worse. Interregional commuting may also affect migration. Finally, there may be a substantial component of migration which is not predict-able on the basis of economic factors, as groups such as retired persons and students move for reasons unrelated to employment. For those groups and others, the relative attractiveness of the region may also be an incentive to move there. Less desirable living environments are less likely to have a "growth problem."

Economic impacts of growth--

The economic effects of growth are expressed in terms of the increase in the production of goods and services that provide people with satisfaction and with the increases in jobs and income that are created in the production of these goods and services. Fiscal impacts - changes in the cost and quality of public goods and services - are a component of overall economic effects and are discussed separately below. Unlike fiscal or physical impacts, which are often confined to limited spatial areas or political jurisdictions, the effects of growth on the economy cannot adequately be analyzed in terms of local impact because growth in one locality will have economic effects that ripple outward through the region.

The benefits derived from the increase in the production of goods and services as a result of growth affect different interests in society depending upon their role within the regional economy. Table IV-A summarizes many of these effects. Consumers receive satisfaction from the increased choice, quantity, type and price of goods and services such as agricultural products, housing, shopping and convenience goods items, personal services, repair services, entertainment and cultural functions and recreational functions. Labor force members benefit from the increase in jobs to produce these goods and services and from the incomes thereby generated. Investors experience increased income benefits as a result of the production process, including incomes from the land values that are created. The profit potential of industrial and commercial interests benefits from economies of scale, advantages of specialization, development of readily available markets within short distances and increases in the ease of communication.

While each type of participant is able to realize a different type of benefit, any one person or entity in society is likely to be able to realize several different types of economic benefits depending upon the roles in which he/she participates. The same is true of the costs of economic growth which arise as a result of the increasing specialization, complexity, size and scale of an urban area. People and firms become more dependent on each other since there are more of them in one area, they are more specialized, and they see each other and must interact more often and with more other people and firms. Choice creates opportunities, but may also in-

Table IV-A. INCIDENCE OF THE ECONOMIC IMPACTS OF GROWTH GENERATED BY INCREASES IN THE PRODUCTION OF GOODS AND SERVICES

Housing consumer	Greater number of housing options of different types and prices.	Increase in congestion as a result of the increase in size and complexity of area. Increase in dependence on neighbors and other members of society.
	Improved quality of housing units.	Difficulty in identifying consumer options.
Consumers of goods and services other than housing	Increased choice of goods and services available in terms of quantity, type and price.	Difficulty in identifying consumer options. Less independence.
Labor force members	Increase in job opportunities. Growth in real incomes.	Increase in competition for jobs. Increase in need for specialized training and experience. Increase in congestion and travel distances.
Capital investors and landowners	Growth of incomes.	Higher risks from increased competition, increased specialization and more rapid technological change.
Industrial and commercial interests and firms	Increases in profit through increases in productivity and lower costs resulting from: economies of scale, advantages of specialization, plentiful labor supply, readily available markets and ease of communication.	Higher risks and increases in failures as a result of more competition, difficulty in discerning market preference and sizes, increased specialization, and more rapid technological change.
Low income households	Labor force members: Job opportunities and real income growth. Greater choice in housing and consumer goods.	Same costs as identified above for consumers and labor force members.
	Retired: Slower increase in housing cost due to expanding supply. Increased value of local investments (if any).	Same costs as identified above for consumers.

Source: Gruen Gruen & Associates

crease risk. These negative aspects of economic growth are also summarized in Table IV-A.

Evaluating the economic costs and benefits of growth--

It has been argued that, at some point, the economic advantages of growth are offset by economic disadvantages. But, despite the intuitive evidence that large metropolises are unpleasant, noisy, congested and timewasting, economic research has yet to find that nay city in the United States has reached the point at which, in the aggregate, marginal economic costs exceed marginal economic benefits (Reference 1000).

However, economic and population growth can assume an infinite variety of forms, the noneconomical impacts of which may significantly differ. Policy approaches available to cope with these noneconomic impacts include planning to accommodate anticipated growth in a manner so as to minimize such costs and adoption of "no growth" or "slow growth" strategies. It should be pointed out that these nonaccommodationist approaches cannot guarantee either the maintenance of present standards of living or environmental quality: "no growth" does not mean "no change." Implementation of a no growth or slow growth objective limits or precludes the conomic benefits to be derived from expansion and may alter the structure of the local or regional economy and the economic opportunities available to local residents.* If economic advantages of growth are not to be curtailed or eliminated, then public concern about the effects of growth should be directed toward identifying and mitigating potentially deleterious impacts while guiding development toward the attainment of regional land use patterns which are environmentally sound.

*By whatever means achieved, a restriction on the rate of population growth will have an impact on the number and type of employment opportunities (the demand for labor) and on the composition and size of the labor force (the supply of labor). A reduction in the growth rate will impact industries differentially depending on whether their level of operation is more closely related to the total size of the economy (for example, retail trade) or to the rate of economic expansion (on which the construction sector is primarily dependent). Cost of no-growth to individuals therefore dependent on their investments and the economic sector(s) on which their livelihoods depend. The reduced new job opportunities discourage in-migration and encourage out-migration, and out-migration normally affects the more highly skilled first, as discussed previously.

Future economic growth in the Denver region--

The Denver Regional Council of Governments (DRCOG) has forecast that employment in the five-county region will more than double during the period from 1970 to 2000, with total employment reaching a level of 1.305 million by the end of the century. Employment is expected to grow most rapidly during the initial portion of the forecast period (increasing 2.7 percent per year between 1975 and 1980) and level off toward the end of the period (increasing 1.8 percent per year between 1990 and 2000) (Reference 259).

The DRCOG forecast is based on projections of historic (1958-1975) total employment and employment by industry group; the results of the trend projection were adjusted in line with observations of the previous (195801965) effects of national growth, industry mix and regional influence on employment growth. Adjustments also were made to insure compatibility between employment and population projections. The industry-by-industry forecast is presented in Table IV-B; the table also includes a projection of the labor force participation rate.

The DRCOG forecast shows declining agricultural employment, which is consistent with agricultural land conversion estimates presented elsewhere in this chapter. All other sectors show significant increases, with the service sector leading the way. Overall, the economy will continue to be oriented more toward the production of services than the production of goods, as was discussed in Section II. The sectors of mining, construction and manufacturing are forecast to decline slightly in terms of their collective share of total nonagricultural jobs, while increases in the service and FIRE (finance, insurance and real estate) sectors will come primarily from reductions in the shares of manufacturing and TCU (transportation, communications and utilitites).

The current DRCOG forecast has not been allocated to counties. Earlier employment forecasting by DRCOG in connection with the Joint Regional Planning Program did consider distribution, and Table IV-C presents an estimate of what the distribution of forecast employment might be, given the county shares projected in the course of that analysis (Reference 262). Figure IV-A shows the changing shares of county employment and population in 1976 and 2000. While Adams and Boulder counties retain their relative shares of the total, and Arapahoe and Jefferson counties increase their share significantly, Denver's share is forecast to decline substantially.

Table IV-B. SECTOR EMPLOYMENT FORECAST FOR THE DENVER REGION, 1975-2000

Industry Sector	Jobs in Thousands				% Change 1975-2000	% of Total Nonagricultural Employment, 2000
	1975	1980	1985	2000		
Agriculture	6.7	6.5	6.4	5.9	-11.9	----
Mining	7.8	8.3	8.9	11.0	+41.0	1.0
Construction	42.5	48.1	53.6	71.5	+68.2	6.4
Manufacturing	94.7	107.1	118.2	154.6	+63.3	13.7
Transportation, Communications and Utilities (TCU)	42.1	45.8	49.8	62.9	+49.4	5.6
Trade	161.6	185.5	206.8	275.6	+70.5	24.5
Finance, Insurance and Real Estate (FIRE)	44.9	52.1	58.4	78.2	$74.2	7.0
Services	143.4	167.0	188.0	260.6	+81.7	23.2
Government (including military)	124.4	124.8	158.6	210.2	+69.0	18.7
TOTAL	668.1	763.2	848.7	1130.5	+69.2	----
Labor Force Participation Rate (total employment ÷ total population)	.453	.462	.471	.481	----	----

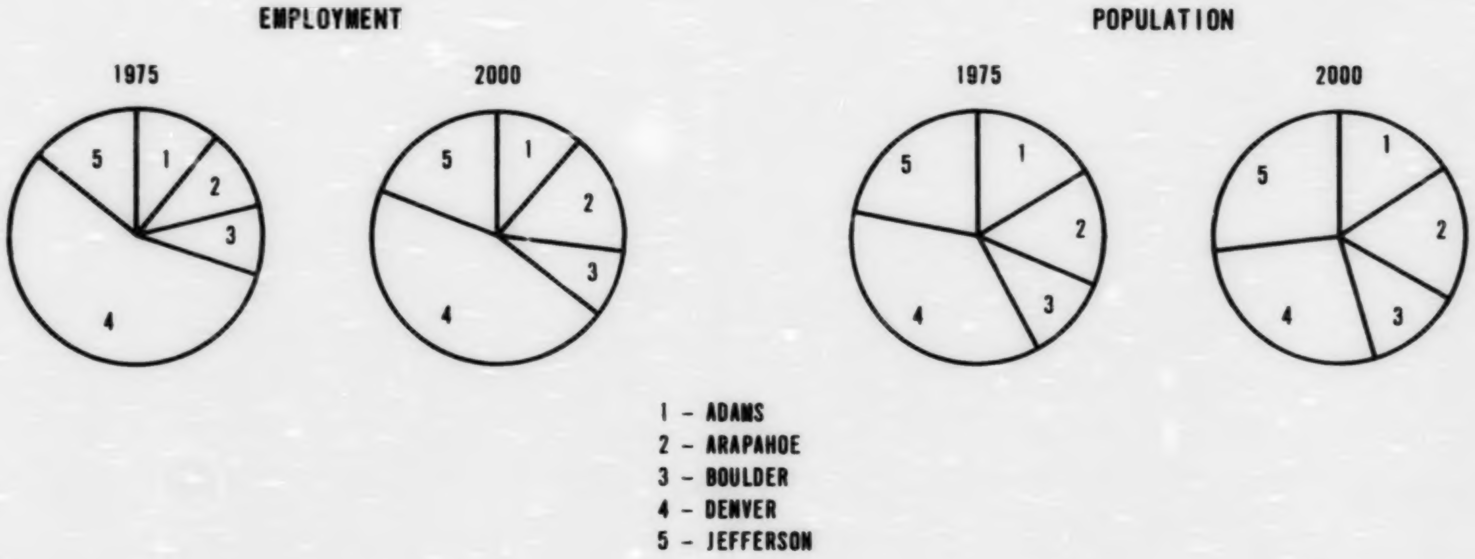
Source: Ref. 259

Table IV-C. EMPLOYMENT PROJECTIONS FOR THE FIVE-COUNTY DENVER REGION

County	Current (1975) Employment	DRCOG Employment Forecast		
		1980	1985	2000
Adams	72,200	85,400	94,500	125,900
Arapahoe	68,400	86,100	106,500	175,800
Boulder	60,400	71,600	78,300	101,200
Denver	371,400	407,600	435,100	513,600
Jefferson	95,700	112,500	134,300	214,000
Total	668,100	763,200	848,700	1,130,500

Source: Totals from Ref. 259; distribution to counties by Gruen Gruen + Associates based on Ref. 262.

FIGURE IV-A



REGIONAL EMPLOYMENT AND POPULATION BY COUNTY

SOURCE: EMPLOYMENT ESTIMATES FROM TABLE IV-C AND POPULATION ESTIMATES FROM REF. 231.

Future population growth in the Denver region--

A year 2000 population forecast of 2.35 million has been adopted by DRCOG as the basis of all its planning activities. This "policy population forecast" incorporates elements both of regional policy and of forecasting. The antecedent of the forecasting element is an earlier forecast by DRCOG of 2.175 million in the year 2000; this forecast was based on (1) the continuation of the 1972 rate of net national increase (8.5 persons per 1,000 population annually) and (2) a gradual tapering off of net in-migration from the high levels (42,000 per year) of 1970-1973. (In the 1975-1980 period, net in-migration is forecast to be 15,700 annually, which was the 1960's rate; by 1980-2000, a further reduction to 15,100 annually is forecast, which was the average during the 1940-1970 period.)

This DRCOG staff forecast was reviewed by the Council, with Council members bringing to the consideration of this issue information from their local jurisdictions. After extensive discussion, the Council of Governments revised the staff forecast upward by 175,000 resulting in the 2.35 million total. The southeastern part of Jefferson County received the bulk of this addition. In January 1973 the amended total was adopted by DRCOG as regional policy.

The net natural increase rates experienced in the last four years are lower than those underlying the DRCOG forecast. Net natural increase declined from 8.5 per 1,000 in 1972 to 6.3 per 1,000 in 1974. Net in-migration has dropped from a 1972 high of 61,400 to about 16,000 per year (preliminary data reported in Reference 993). (The addition of 175,000 to the original forecast results in an implicit change in the forecast of in-migration, which would have to be 22,000 persons per year if the year 2000 forecast of 2.35 million is to be attained (Reference 993). Whether the net natural increase rate will stabilize at a lower level, or the net in-migration will continue to decline, is not known. However, the DRCOG forecast can be seen as describing a reasonable upper limit to regional population growth.

Community Services and Facilities

The increase in population and economic activity forecast to take place by the year 2000 has implications for the provision of public services and facilities through the region. Among the services which will face increased demand are sewage collection and treatment; water supply fire and police protection; garbage collection and disposal; roads and other transportation services and public works projects; education; general governmental services; and parks and recreation. One study of growth in the Denver area found that, to serve an additional 1,000 persons, an additional 12 acres of public institutional uses and parks, 13 acres of streets, seven school classrooms, 150,000 gallons of water per day, two firemen and three policemen would have to be supplied (Reference 307).

The added community services and facilities will result in an increase in the costs of the government agencies which supply them. At the same time, new development will increase the local tax base. The fiscal impact of growth is individual to the service-providing entities; the regional fiscal impact of growth is only the aggregate of the local impacts, a point receiving further discussion in the next section. The investigation of the impacts of growth on public service requirements in the Denver region is part of the study program of the Denver Metro Environmental Analysis commissioned by the U.S. Department of Housing and Urban Development; this study has not attempted to quantify these impacts.

Costs, Financing and Fiscal Impacts

The major fiscal issue related to grow in that of whether the provision of public services to new users will affect the quality or quantity of services to existing users and of whether existing costs will be affected. The often-heard question of whether growth pays for itself is usually directed to the concern that the provision of public services to new users could increase the costs to all those paying taxes and user charges without increasing or improving the service outputs to existing users. For example, the Boulder Valley Comprehensive Plan establishes a policy that "new growth should bear the major expense of self-created needs for community services and facilities to the immediate neighborhood" (Reference 1012).

As shown in Table IV-D, there are circumstances in which the costs of providing additional public services exceed the revenue generated by the new users and new taxpayers so that the net result of fiscal impact is an increase in costs to all users and taxpayers within the relevant public service jurisdiction.

It is not possible to generalize as to whether new development will have a positive or negative fiscal impact on existing service users and taxpayers. The fiscal outcome is determined by five variables:

- the make-up of the existing population and development;
- the type of development experienced (scale, type and value of land used);
- the state of capital facilities in the relevant service districts at the time the demand for service increases (i.e., the presence or absence of unused capacity);

Table IV-D. INCIDENCE OF THE FISCAL IMPACTS OF GROWTH GENERATED BY AN INCREASE IN THE DEMAND FOR PUBLIC SERVICES

Interest of Actor	Benefit	Cost
Recipients of additional public service outputs (such as new residents).	Public service outputs.	Public taxes and user charges.
Existing taxpayers and existing recipients of public services in jurisdictions providing the additional public service outputs.	Reduced taxes and user charges if new users generate a net surplus of revenue over costs[a].	Increased taxes and user charges if new users generate a net deficit of costs over revenues[a].
Local municipalities and special purpose districts providing the additional service outputs.	A net fiscal surplus if revenues exceed costs.	A net fiscal deficit if costs exceed revenues.
Local municipalities and special purpose districts other than those providing the additional public service outputs.	Avoidance of service system expansion (if efficient levels of operation have been reached).	Failure to achieve efficient levels of operation (if now operating at lower than optimum rate of output).
Existing taxpayers and existing recipients of public services in jurisdiction other than those providing the additional public service outputs	Indirect benefits or costs depending upon which of the two conditions above apply.	

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[a] Circumstances under which these conditions would be experienced are discussed in the text.

Source: Gruen Gruen + Associates

- the laws and policies concerning the types of taxes that are used to pay for the various kinds of public services; and
- the policies that the relevant service districts apply to the setting of tap fees and user charges.

COST CONSIDERATIONS

There are two factors which largely determine the impacts of growth on the cost of a particular public service. There are (1) the proportion of total costs represented by fixed or capital costs, and (2) the excess capacity of existing facilities,

A sewage treatment plant provides a service where a high proportion of total costs are fixed. Therefore, if the plant has excess capacity, ther per unit cost (dollars per unit of wastewater treated) would decrease with population growth because fixed costs are spread over a larger base. However, if existing facilities are operating at capacity, new facilities would have to be built to accommodate additional population and per unit costs would go up.

For services with low fixed cost compared to total cost, an increase in demand is unlikely to increase per unit costs. Police protection and schools are examples of these kind of services. The per unit costs of these services are more affected by the quality of service demanded by a community than by population growth.

Revenue considerations--

The net fiscal impact depends on the particular nature of the user charges and tax rates for generating service revenues as well as on the relationship between the revenues generated and the applicable set of costs, determined as discussed above. Many local public services are supported primarily by property taxes. While it is true that higher valued properties can generate higher tax revenues than can those of lower value, there is no property value level at which, as a rule of thumb, one could say that a net fiscal surplus will or will not result. It is the present and future mix of land uses - in terms of type and value - that determines net fiscal impact. There are differences among land use categories in terms of their demand for services and the revenues they generate. Industrial and commercial uses, for example, do not directly generate demand for educational services although they generate revenue to the school districts providing those services. Residential uses, on the other hand, do generate education costs; whether they also generate enough revenues to offset those costs depends on the value of the development and the number of school-age children it houses.

Net fiscal impacts and land use planning--

The type of growth a particular community experiences will influence its future service requirements and costs, and will determine its revenues as well. When viewed from a regional perspective, growth per se is likely to bring a mix of uses, including residential uses which provide housing for the workers in the industries and commercial establishments. "Less fiscally desirable" uses must go somewhere within the region if the "more fiscally desirable" ones are to continue to exist there. But, though a balance of uses may exist in the region as a whole, a local community may have a higher than average share of either type of development, depending on the community's location, market assets and the historic land use mix. An individual community may attempt to influence its fiscal condition by attracting "high value" development (such as major retail or industrial uses) and discouraging "low value" development (such as inexpensive housing with high demand for public education). This kind of fiscal rivalry can result in less efficient regional land use patterns.

On a local area basis, land use patterns can be planned to minimize the costs of providing government services. For example, higher density residential development may have lower per-unit road requirements and thus lower unit costs for roads; this results in lower unit costs for street lighting and street maintenance.

However, even where land use patterns are designed to minimize costs, this does not guarantee that revenues will exceed costs or, more important, that development in that location would be the least costly. Certainly that development would not be least costly in the short run if it requires the construction of new facilities while excess capacity for services exists elsewhere in the region at a location which the new use would accept.

While fiscal impacts are of importance to taxpayers and to public service users, public decision makers would be aware that fiscal impact is only part of a project's economic impact. Fiscal impact analysis considers only those costs and benefits which appear as cash flowing in and out of a particular local government treasury. It omits privately received costs and benefits as well as the interdependencies between types of land uses and among different public service jurisdictions. It also says nothing about the economic desirability of land uses. Thus, the question "does growth pay for itself" cannot be answered from the rather narrow perspective of fiscal impacts alone. A development with a negative fiscal impact may still be desirable, and a development which promises to be a local fiscal asset may nevertheless be undesirable. There are other impacts against which the fiscal impacts must be balance.

Impacts of Wastewater System Costs--

The costs Denver communities will pay for wastewater facilities described elsewhere in this report are summarized in Table IV-E.

The 208 Plan has estimated a total capital cost to the five county region of 70 million dollars through 1985 to obtain the desired water quality levels specified in the Plan. The figure was calculated using an 8% inflation factor for the years 1977-1982. Beyond 1982 an inflation factor was not used. Through year 2000 an additional 40 million dollars of capital expenditures are expected for treatment system expansion and upgrading. The present worth cost for both capital and O & M for collection systems, through the year 2000 is 257 million dollars for the 208's recommended plan for municipal wastewater treatment plants. The 208's cost estimate to meet the 1983 goals is 292 million dollars annually of which 37 million dollars per year is for municipal wastewater control.

Some portion of these costs will pay for expansion of wastewater treatment capacity, and these are the costs associated with growth. The remainder of the costs will finance changes in waste treatment operations to result in a treated waste product less damaging to the environment. This represents an increase in service quality (though it is being undertaken more in response to federal regulation than to local demand) and is therefore appropriately borne by native and new resident alike. The facility plans have not broken costs down by these two categories--system expansion and upgrading of treatment levels. The additional information on growth accommodation and facility plan objectives presented in Table IV-E provides a basis for making this type of determination. It must be kept in mind that other projects such as the Denver Northside and MDSSD No. 1 wastewater treatment complex expansion and the new Littleton/Englewood regional plant are under construction. From the information presented in Table IV-E, it can be estimated that about one-half the total estimated cost for the next five to seven years is for growth accommodation.

The 208 study has estimated that approximately 65 percent of the total capital cost through the year 2000 are growth induced costs. In total dollars this would amount to about $200 million out of the $310 million projected for capital improvements excluding collection system, operation and maintenance costs.

No per capita cost estimates are presented in the eight 201 facilities plans for their respective service areas. The 208 Plan has projected an average per capita cost of about $150 based on the year 1985 cost estimate to achieve desired water quality levels

Table IV-E. ESTIMATED AGGREGATE CAPITAL COSTS OF WASTEWATER FACILITIES ALTERNATIVES (MILLIONS OF 1976 DOLLARS THROUGH 1983

Planning Area	Local	Regional	No-Action	% of Growth to 2000 Accommodated	Facility Plan Objectives	
					Capacity	Improved Treatment
South Adams County	4	6	4	Less than 1%		X
Englewood/Littleton	5	3	2	24% [a]		X
South Lakewood	11	6	5	2.5%		X
Cherry Creek-Goldsmith Gulch	24	24	22	13%	X	
Clear and Sand Creeks	33	38	30	23%	X	X
Westminster/Bloomfield	11	5	7	7%	X	
Lower South Platte	17	13	14	7.5%	X	
MDSSD No. 1	14	17	14	b		X
Total Estimated Cost	119	112	98[c]			
local Agency Share	30	28	98			
EPA Grant Funds	89	84	0			
Construction Employment						
Person-years	4,100	3,860	3,380[a]			

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a. The Littleton/Englewood satellite plant now under construction is expected to accomodate growth till 1983 (20 mgd). Another capacity expansion would be required, and evaluated in an EIS, at that time.

b. MDSSD No. 1 would treat, under the local alternative, partial flows from Clear and Sand Creeks, flows from Cherry Creek/Goldsmith Gulch after primary treatment at the Denver Northside Plant, as well as flows from other areas not covered by listed planning areas. Capacity expansion now under construction. Further additions to capacity would be to accomodate growth.

c. An estimated $10 million additional would be expended after 1983 with about 345 person-years construction employment.

and the 1985 projected population of 1.8 million people.

The data presented in Table IV-E cover estimated costs of wastewater prjects in six service areas. The South Adams County Water and Sanitation District's current facilities plan calls for an initial capital improvement program involving approximately $3 million, of which most is eligible for federal funding (Reference 509). The plan presumes that 75 percent of the cost will be federally funded, with the local portion to be financed by the sale of bonds. The district meets all requirements for federal grant funds.

Englewood and Littleton have already received federal funds for construction of a jointly operated plant to provide treatment up to the secondary level and will probably apply for grants for future improvements to that plant. The cities are financially sound and appear to meet all requirements for federal grant-funding.

The City and County of Denver proposes additonal interceptors in the Cherry Creek area. The only source of long-term debt financing available to City and County of Denver is revenue bonds of the Wastewater management Division. The sale of revenue bonds must be approved by the City Council, as must any increases in user charges (Reference 225).

The Metropolitan Denver Sanitary Disposal District No. 1 (MDSDD #1) proposes future expansion of its main plant and upgraded treatment to be financed in part by state and federal grants and in part by the sale of revenue bonds (Reference 318). For MDSDD #1 to qualify for federal grant funds, all the user districts must conform to federal grant standards; apparently not all conform at present. This problem has caused delays in allocation of federal grant money in the past (Reference 225), and MDSDD #1 does not have any control over the means by which member districts raise revenues. The District itself was authorized to issue some $30 million in revenue bonds, of which $20 million had been sold by 1973 for capital improvements currently being completed. This means that about an additional $10 million worth of bonds can be issued without further voter approval. Beyond that amount, MDSDD # 1 would have to obtain voter approval for a subsequent bond issue. It has been reported that there may be some resistance by district users to any further service charges or additional revenue bonds in the future (Reference 225). Given the likelihood of voter resistance to substantially increased charges, if federal grant funds are not forthcoming, it is unlikely that MDSDD #1 would be able to raise sufficient capital to pay for much more construction.

Future treatment plan expansion by the Cities of Broomfield Westminster is proposed to be financed in part by Federal grants. Both cities have received federal funds in the past, and both seem to meet requirements for future federal funding. However, if grant money were not made available, the cities would probably raise substantial capital by sale of more revenue bonds. To what extent each city would be willing and able to sell these bonds is not known.

The South Lakewood Sanitation District (SLSD) intends to apply for a federal grant for expansion of its treatment plant and upgrading of treatment to meet July 1977, standards. A facility plan is currently being prepared for these improvements. In case the SLSD's reliance on property tax revenue proves unacceptable for federal funding purposes, discontinuation of ad valorem taxation would be considered.

Estimates of effects of the costs of proposed facilities on user charges, tap fees, etc., are not available. Increases will occur, their magnitude is not as yet known. Some estimates can be made as to whether current resident or new residents will bear the majority of the capital costs of new facilities. Over a twenty-five year period, and a net growth rate of about two percent, 55-60 percent of the cost of new facilities would be borne by new residents. At a higher growth rate of four percent, the cost percentage increases to a range of 65-70 percent.

LAND USE CHANGE TO THE YEAR 2000

Between 1960 and 1970, the Denver region experienced an acceleration in suburbanization as the City and County of Denver became less dominant in terms of population concentration, though it continued to be the region's main job center. In the late 1960's, and especially in the first part of the 1970's, employment has also become more widely dispersed through the region, with the City and County of Denver accounting for a declining share of regional employment. These changes have been accompanied by changes in land use patterns, with the suburban counties (Adams, Arapahoe, Boulder and Jefferson) experiencing increases in developed acreages and losses in agricultural and vacant acreage. These kinds of changes are unique neither to the 1960's nor to Denver: the pattern is common throughout the country, and it has every likelihood of continuing in the Denver region through the end of the century.

Future Land Use Change

In tabulating land use data, eight use categories have been established, and DRCOG has project acreage in each use by census tract as a function of future population and employment. This tabulation, aggregated by county is presented in Table IV-F.

Table IV-F. COUNTY LAND USE SUMMARY, 19070 and 2000

County and Year	Residential Single-family	Residential Multi-family	Commercial	Services	Industrial, Transportation Communications[a]	Parks and Recreation	Public and Semi-Public	Agriculture, Undevelopable and Other Vacant	Total
Adams[b]									
1970	9,249	888	956	145	12,268	1,151	18,591	[illegible],292	
2000	20,547	2,481	1,825	306	16,392	2,439	19,878	[illegible],672	146,540
Change	11,298	1,593	869	161	4,124	1,288	1,287	-20,620	
Arapahoe[b]									
1970	8,498	519	595	254	7,115	2,951	4,662	66,169	
2000	18,456	1,532	1,498	527	12,589	4,054	7,128	44,979	90,763
Change	9,958	1,013	903	273	5,474	1,103	2,466	-21,190	
Boulder[b]									
1970	9,427	946	892	153	8,251	6,726	1,956	135,949	
2000	17,000	2,358	1,697	332	13,471	6,919	2,967	119,556	164,300
Change	7,573	1,412	805	179	5,220	193	1,011	-16,393	
Denver									
1970	21,505	3,296	1,975	720	28,687	6,102	4,382	25,336	
2000	23,167	4,254	3,019	788	32,761	6,578	5,088	16,348	92,003
Change	1,662	958	1,044	68	4,074	476	706	-8,988	
Jefferson									
1970	15,020	838	1,174	966	15,430	1,754	5,928	93,011	
2000	26,684	2,300	1,983	1,146	20,348	3,074	6,352	72,234	134,121
Change	11,664	1,462	809	180	4,918	1,320	424	-20,777	
Total[b]									
1970	63,699	6,487	5,592	2,238	71,751	18,684	35,519	423,757	
2000	105,854	12,925	10,022	3,099	95,561	23,064	41,413	335,789	627,727
Change	42,155	6,438	4,430	861	23,810	4,380	5,894	-87,968	

[a] Includes streets

[b] Excludes portions of these counties lying outside Denver metropolitan region as defined by DRCOG (Reference 261).

Source: Acreage for 1970 from Reference 205 and for 2000 from Reference 261; figures for both years aggregated on the basis of 1970 census tracts as described by DRCOG (Mugler, pers. comm., February 10, 1977).

In reviewing the land use projections, the reader should keep several factors in mind. First, the data does not cover the five counties in their entirety, but only the portions which form part of the Denver metropolitan area. Thus, eastern Adams and Arapahoe and Western Boulder Counties have not been included in the tabulation. Second, the boundary delineating the Denver metropolitan area for the purpose of land use tabulation was changed by DRCOG after the 1960-1970 tabulation. The redefinition resulted in the exclusion from the study area of large blocks of land in Adams, Arapahoe and Boulder counties. In Table IV-F, the figures for 1970 have been reduced by appropriate amounts in the relevant categories (generally agricultural, undevelopable and other vacant) so that figures for 1970 and 2000 cover the same area, but the total acreage figures differ from those in Table II-F. Finally, the land use projections of CRCOG are from the fourth-cycle runs of the EMPIRIC land use forecasting model, which preceded the adoption of subarea population allocations. To the extent the adopted population allocations (which in some cases are still in dispute) differ from the population figures utilized in the computer projections, the year 2000 land use projections. Notwithstanding this limitation, however, much can be learned from the land use projections about the future pattern of land development in the Denver region.

All categories of developed land show substantial acreage increases over the 30-year period. The largest percentage increase is in multi-family residential acreage, which is projected to double by the year 2000. Single-family residential acreage will increase by about two-thirds, and commercial acreage by almost 80 percent. Land use in all other categories is projected to increase by at least 15 percent with the exception of undeveloped (the category headed agriculture, undevelopable and other vacant), which is projected to decline by about 21 percent.

Regional Development Patterns

The date presented in Table IV-G offers another way to consider future land use change in the Denver region: the percentage of total regional land in a given use category represented by each county's land in that category is listed for both 1970 and 2000. These data offer an indication of changes in the roles played by the counties in the regional context. The last row shows the percentage of land in each county which was classified as developed in the years 1970 and 2000. The most striking change between 1970 and 2000 is the increase in the percentage of developed land. In Adams, Arapahoe and Jefferson counties, the degree of urbanization in 2000 as indicated by this measure will exceed that of Denver (36.9 percent in 1970). Only Boulder County is projected to retain a comparatively rural develop-

TABLE IV-G. PERCENTAGE DISTRIBUTION OF LAND BY USE CATEGORY, 1970 and 2000

Land use category	Adams		Arapahoe		Boulder		Denver		Jefferson		Total Land by Land Use Category	
	1970	2000	1970	2000	1970	2000	1970	2000	1970	2000	1970	2000
Residential	14.4[a]	19.4	12.8	16.8	14.8	16.3	35.3	23.1	22.6	11.2	11.2	18.9
Commercial and Service	14.1	16.2	10.8	15.4	13.3	15.5	34.4	29.0	27.3	23.8	1.2	2.1
Industrial, Transportation, Communications	17.1	17.1	9.9	13.2	11.5	14.1	40.0	34.3	21.5	21.3	11.4	15.2
Parks, Recreation, Public and semi-public	36.4	34.6	14.0	17.3	16.0	15.3	19.3	18.1	14.2	14.6	8.6	10.3
Agriculture, Undevelopable, Other Vacant	24.4	24.6	15.6	13.4	35.6	6.0	6.0	4.9	21.9	21.5	67.5	53.5
% of Land Developed[b]	28.7	41.9	23.8	46.0	23.0	36.9	36.9	42.0	29.3	43.9	29.5	42.8

[a] Represents county share of regional total for specified land use.

[b] Includes all categories except (1) parks and recreation and (2) agricultural, undevelopable and other vacant, and represents percentage of land developed in each county.

Source: Table IV-F.

ment pattern, with less than 23 percent of its land developed. Even though Boulder is projected to lose 16 thousand acres of undeveloped land to development over the 30-year period, it will have a slightly higher proportion of the region's undeveloped land in 2000 (35.6 percent) than it had in 1970 (32.1 percent).

In the year 2000, the City and County of Denver will have a reduced share of regional developed land in all categories, as shown in Table IV-G; Denver's actual acreage increases, shown in Table IV-F, are small compared to those of othe other counties. Jefferson County will become more "suburban" than it was in 1970: residential use will rise by over 80 percent, while land used for employment activities (commercial, services, industiral, transportation and communications) is projected to grow only 34 percent.

Future land use is hsown on Map I. This future land use map was developed by DRCOG, and was based upon population and land use computer projections which have since been superceded as previously discussed. Map I and Figure IV-B, nevertheless are useful in illustrating where future growth is expected to occur. Map I should be compared to Map H, and Figure IV-B should be compared to Map B. Map I incorporates certain planning policies which diminishes its relationship to the real world. As an example, the future land use shown excludes floodplains and streamside areas from development that is clearly known and shown to currently exist on Map H of current land use. Thus Map I show not expected land use, but desired land use given certain development policies.

The projections imply some changes in the density of new development over the 30-year period. In 1970, there were about 17 persons per acre of land in residential use; in 2000, the projections indicate about 19 persons per acre. This means that new development would be somewhat more dense than residential development in 1970, with about 23 persons per acre being the average density of new development. Employment uses are also projected to be more densely developed in the future, rising from about 0.7 employees per acre of employment land (which includes commercial, services, industrial, transportation and communications) to about one employee per acre in 2000. (These estimates understate actual employee density because street acreage figures are included in employment land use. However, that does not affect the direction of change.

The projections of land in park and recreation use indicate an increase of over 4 million acres by the year 2000, an increase of 23 percent over the 1970 acreage. However, residential development and population growth are projected to exceed that rate of increase.

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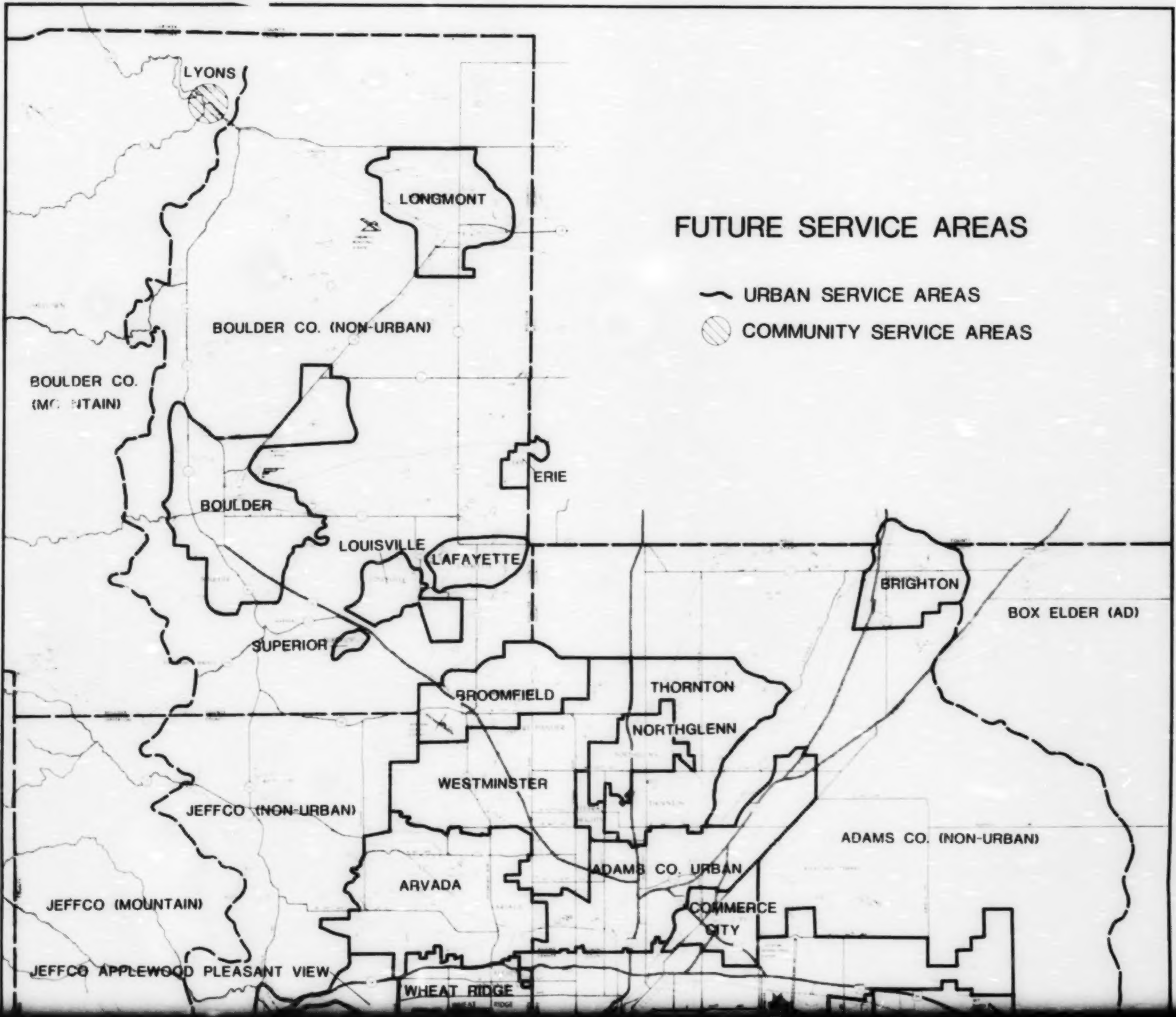
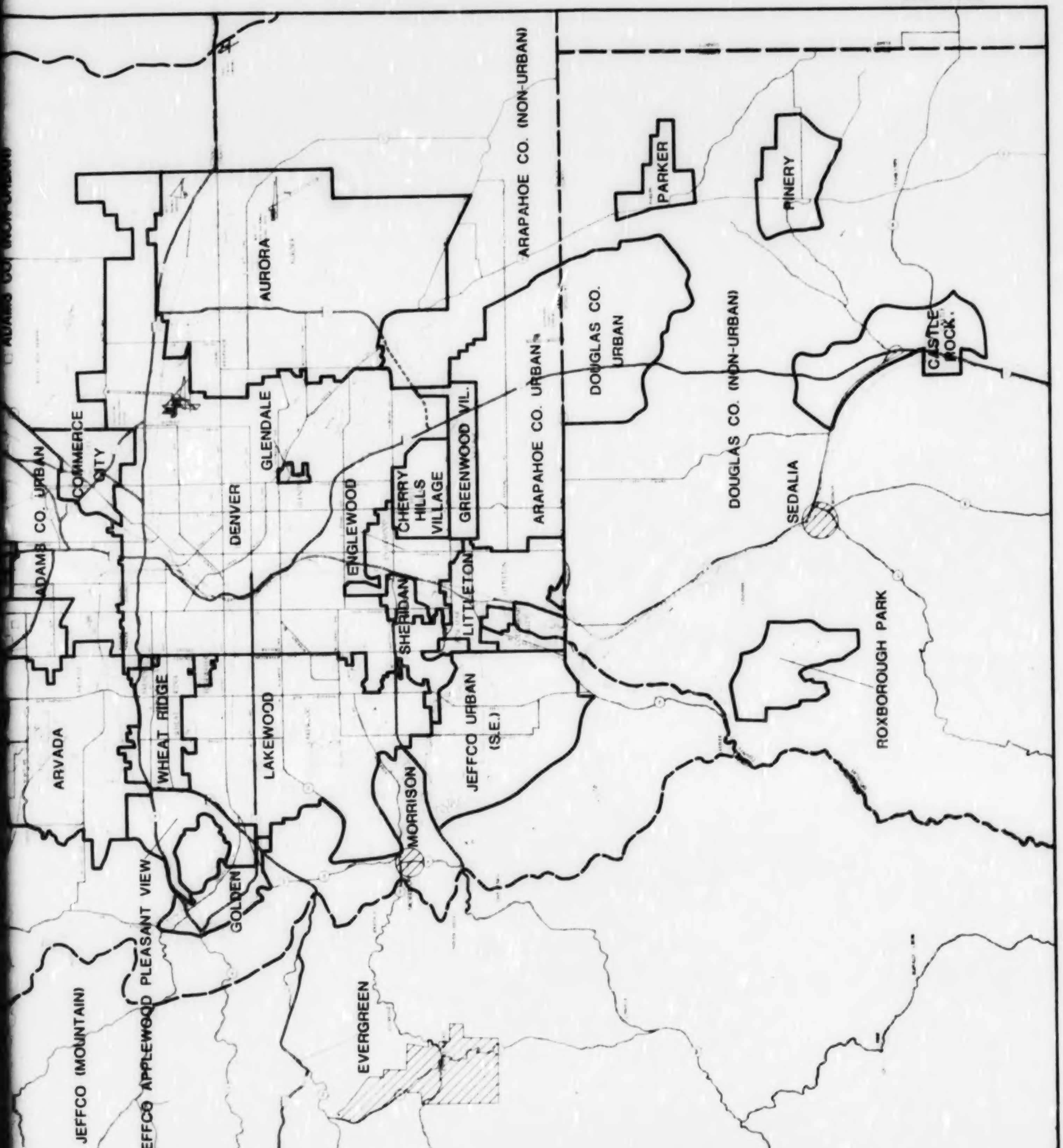


FUTURE SERVICE AREAS

URBAN SERVICE AREAS
COMMUNITY SERVICE AREAS
LYONS
LONGMONT
BOULDER CO. (NON-URBAN)
BOULDER CO. (MOUNTAIN)
ERIE
BOULDER
LOUISVILLE
LAFAYETTE
SUPERIOR
BRIGHTON
BOX ELDER (AD)
THORNTON
BROOMFIELD
NORTHGLENN
WESTMINSTER
JEFFCO (NON-URBAN)
ADAMS CO. (NON-URBAN)
ADAMS CO. URBAN
ARVADA
JEFFCO (MOUNTAIN)
COMMERCE CITY
JEFFCO APPLEWOOD PLEASANT VIEW
WHEAT RIDGE

FIGURE IV-B


ADAMS CO. (NON-URBAN)
ADAMS CO. URBAN
COMMERCE CITY
ARVADA
WHEAT RIDGE
LAKEWOOD
DENVER
GLENDALE
AURORA
ARAPAHOE CO. (NON-URBAN)
ENGLEWOOD
CHERRY HILLS VILLAGE
GREENWOOD VIL.
ARAPAHOE CO. URBAN
ARAPAHOE CO. URBAN
SHERIDAN
LITTLETON
JEFFCO URBAN (S.E.)
MORRISON
GOLDEN
JEFFCO APPLEWOOD PLEASANT VIEW
JEFFCO (MOUNTAIN)
EVERGREEN
DOUGLAS CO. URBAN
DOUGLAS CO. (NON-URBAN)
DOUGLAS CO. (NON-URBAN)
PARKER
RINERY
CASTLE ROCK
SEDALIA
ROXBOROUGH PARK

This means that park acreage per capita is projected to decline by 35 percent, from 15.2 acres per capita to 9.8 acres per capita, between 1970 and 2000. Although regional open space particularly outside the urban areas will be ample, opportunities for active recreation in the urban areas will be significantly diminished. Even without an increase in recreational demand, recreation areas will be more intensely used and degraded.

Regional Planning Issues

Land use patterns and environmental quality are intimately related. The magnitude, location, rate and spatial distribution of new development has important effects on the provision of public and private services, on environmental pollution and on the preservation of stable ecosystems. Elsewhere in this report the impacts of Denver's future growth on the natural environment (air quality, water quality, ecosystems and production of food and fiber) have been described. In this section, the efforts of local and regional agencies to guide development so as to minimize its adverse environmental effects are reviewed. State policies were enumerated in early 1976 by Governor Lamb and are reproduced in Appendix A. The adopted planning policies of the Denver Regional Council of Governments are also included in their entirety in Appendix A. Within the context of these policies, possible steps to improve the effectiveness of local and regional planning are discussed, particularly with regard to wastewater facilities planning.

Efficiency of Future Development Patterns

Recent literature in planning and regional science has reported on a number of studies of the relationship between the spatial configuration of land development and its environmental consequences. These studies typically have found that major land uses have different environmental effects, depending on the pattern of development, and that a pattern of land development which includes dense concentrations of mutually supportive, interacting land uses offers important advantages not offered by dispersed development patterns.

The environmental effects of densely concentrated activity are often readily apparent. The demand for utilities and energy at a site of concentrated activity is high; traffic volumes result in congestion noise, and concentrated emission; high percentages of impervious surfaces result in microclimatic changes, reductions in groundwater recharge capabilities and possible increased problems in accommodating stormwater runoff. However, these direct effects may be the same whether the uses are concentrated or free-standing; the concentration of activities draws our attention to these impacts but does not necessarily increase the magnitude of impacts. In fact, the indirect effects of concentration may result in superior environmental impacts,

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both in reducing environmental degradation below that which would result from dispersed patterns of development and in providing improved economic opportunities. Beneficial effects of concentrating land uses in "activity centers" include (1) expansion of consumer choice (by providing desirable residential locations for those to whom high density living is appealing), (2) increasing potential income to firms and individuals (due to gains in efficiency in communication and exchange of goods made possible by proximate locations of activities) and (3) reduction in the indirect effects of development on the environment (by encouraging multipurpose trips, and by making walking and collective forms of transportation reasonable alternatives to the automobile).

The activity center concept is a key element in the year 2000 plan for the Denver region, and a number of areas have been designated as activity centers or corridors; these are listed in Table IV-H. These areas are not yet fully developed (compare current population and employment to year 2000 population and employment), but the development of a complex interaction of densely concentrated land uses at these sites, supportive of higher density living and public transportation service, is the objective.

The objective of encouraging a more efficient land use pattern by encouraging activity center development faces a number of impediments. First, the local jurisdictions with direct land use planning responsibility implement it unevenly. Arapahoe County is an example of one jurisdiction which plans to work toward high density levels along designated travel corridors, in part in the hope that rail rapid transit service will eventually be provided (higher density development may indeed be a precondition for it). Other communities recognize advantages in higher density housing that are economic as well as environmental: lower land costs per unit put the higher density unit in the reach of more households; smaller units are appropriate in a period of declining household size and declining real incomes; densely concentrated development has (typically) lower public service costs per unit. But proposals for dense residential developments often meet public opposition, with blockage of views, interruption of scenic corridors and changes in community character given as reasons for public objections to high density development. With the majority, especially of the suburban public, lukewarm to the concept at best, it is not surprising that most planners in the region report that the bulk of future residential development will be low density and single--amily ("the market preference of the Denver region," according to a Westminster planner) with overall residential densities declining by the year 2000 as discussed in the preceding section.

A second factor working against the effectiveness of the activity center as a planning tool is the increasing dispersal of industrial employment. Recent history suggests that isolated sites have a significant appeal to those making site-selection decisions for major industrial facilities. Examples of industrial-location decisions fitting this pattern include Storage Technology Corporations (Louisville), Western Electric (Westminster), Michelin (Littleton) and Johns-Manville (Jefferson County). The Johns-Manville location has received considerable publicity, and is an excellent demonstration of the role of corporate image in location decisions. The firm's former chief executive officer-the man who selected the Ken-Caryl Ranch as the site for the J-M facility-described his decision in these terms: "A company's headquarters is its signature. I wanted a new signature for J-M". (Reference 1018). Image, provision for expansion space, desirable local characteristic such as lower taxes, lower land prices, more lenient development controls - these factors may all play a role in the selection of isolated sites by major employers and may reduce the incentive for firms to locate in activity centers.

A third factor which may be weakening the activity center planning strategy is the decision not to fund mass transit by the Urban Mass Transit Administration. Mass transit is not a precondition to the success of an activity center's policy; however, the coordination of land use planning policy with mass transit might have resulted in local zoning and planning patterns more strongly reinforcing existing activity centers along the proposed mass transit corridor. With hopes for rail mass transit dashed, there is a loss of incentive to encourage high density uses - residential and commercial - in the travel corridor (which would have linked together a number of the designated activity centers).

A fourth factor which favors the dispersal of economic activity throughout the region is competition among communities for property tax revenues. Fiscal rivalry weakens the regional perspective in land use decisions. The Denver Chamber of Commerce objected to Michelin's decision to locate along the southern edge of Littleton rather than at a site closer to the residential areas where most Michelin workers will probably live (Payne, personal communications). Of course, the cities of the Denver region cannot be faulted for pursuing their fiscal self-interest in trying to attract industry to locations within their perimeters, but local dependence on property tax revenues represents a significant institutional impediment to the implementation of regional land use policies based on nonfiscal-environmental and social welfare-criteria.

Population Growth--

As discussed in Section II, apolicy population forecast for the Denver region has been adopted by the Denver Regional Council of Governments (DRCOG) which is expected to serve as the basis for the planning of regional facilities throughout the five-county metropolitan area. DRCOG has allocated a year 2000 population of 2.35 million persons to geographic units called urban service areas, which generally correspond to local government planning areas. These service areas are shown in Figure II-B, and the population allocations are given in Table IV-H.

TABLE IV-H. REGIONAL SUBAREA POPULATION ALLOCATION BY SERVICE AREA

Service Area	Current 1975	Short Term 1985	Long Term 2000
Mountain	29,600	40,000	55,500
Boulder Co Mtn	5,900	6,700	7.900
Evergreen*	7,800	12,000	16,800
Jefferson Co Mtn	14,200	18,700	26,800
Lyons*	1,000	1,600	2,500
Nederland*	700	1,100	1,500
Plains	4,400	6,800	9,900
Bennett*	900	1,700	2,300
Box Elder (Ad)	400	700	1,100
Box Elder (Ar)	400	500	600
Byers*	400	700	1,000
Deer Trail*	400	400	400
East Plains (Ad)	200	600	100
East Plains (Ar)	700	700	1,400
Strasburg*	1,000	1,500	3,000
Valley	1,439,800	1,755,700	2,284,600
Adams Co (Uninc)	10,500	14,200	14,800
Adams Co (Urban)	62,500	71,400	83,100
Arap Co (Uninc)	700	900	1,200
Arap Co (Urban)	35,900	39,900	79,300
Arvada	80,800	94,800	117,400
Aurora	121,700	157,000	228,700
Boulder City	92,200	106,700	130,100
Boulder Co (E Uninc)	13,300	17,300	24,700
Bow Mar	1,100	1,300	1,300
Brighton	12,900	18,000	25,000
Broomfield	16,400	29,700	44,500
Valley (Cont'd)			
Cherry Hills Village	5.400	8,300	10,700
Columbine Vall	600	600	600
Commerce City	18,600	19,500	20,000
Denver	532,300	566,100	646,700
Edgewater	5,500	5,600	5,900
Englewood	35,900	40,900	45,900
Erie**	100	300	800
Federal Heights	7.600	9,900	12,900
Glendale	3,700	8,700	8,700
Golden	14,500	18,600	26,000
Greenwood Village	3,500	5,200	10,000
Jefferson (A-P)***	9,500	11,600	15,200
Jefferson (SE Urban)	21,200	68,200	137,900
Jefferson (Uninc)	200	6,000	12,000
Lafayette	5.800	10,200	14,000
Lakewood	123,000	163,700	213,600
Lakeside	****	****	****
Littleton	33,500	38,000	47,300
Longmont	34,200	46,300	67,400
Louisville	3,700	10,000	13,600
Morrison*	500	600	800
Mountain View	800	800	800
Northglenn	31,500	36,700	38,600
Sheridan	6,000	8,100	13,200
Superior	300	400	500
Thornton	27,600	39,500	65,500
Westminster	31,600	40,700	58,900
Wheat Ridge	34,300	40,000	47,000
5-County Region	1,473,800	1,802,500	2,350.000

*Community Service Area
**Allocation for part in Boulder County only.
***A-P - Applewood-Pleasantview.
****Less than 50.

Local agency forecasts were one source of information to DRCOG's allocation process. These forecasts vary widely in methods and assumptions. A number of the local agencies have expressed the view that DRCOG ignored their work and have questioned DRCOG's allocation approach, which allocates shares of regional growth to counties and allocates the county shares among subareas within the counties. Local planners feel this approach has often disregarded the demand for development in their jurisdictions and their capability of providing services and facilities supportive of new development. DRCOG's communications with local agencies have stressed that local area forecasts must take into account uncertainties with regard to the future availability of wastewater treatment and how these services would be financed.

Although the majority of the local jurisdictions agreed to DRCOG's allocation, a few did not. Even the provision of a permissable latitude of 15 percent between the DRCOG allocation and the local forecasts was not enough to accommodate the discrepancies. The allocations for Arvada, Aurora, Boulder, Broomfield, Lakewood, Longmont, southeast Jefferson County, Thornton and Westminster service areas were still in dispute between the local agencies and DRCOG. In general, those disagreeing with DRCOG's allocation represent potential high-growth areas, and the local agency projections exceed those of DRCOG:

> *In all of these areas, high short-tem building rates are projected, and local policy encourages rapid growth. In the 1975-1980 period, the local total projected increase for these areas is 189,300 and represents a combined annual growth rate of 5.2 percent compared to a rate of 2.3 percent for regional forecast staging. The regional subarea population allocation to these growth areas for the same period is 115,300.* (Reference 231)

Disparities between regional and local forecasts are of considerable concern to local governments because local agency applications for federal funds are subject to DRCOG review. The regional council could, at least in theory, determine the size of the grant or whether a given project would be funded. Local agencies believe that, if they attempt to obtain federal funds for wastewater treatment facilities sized to serve a planning period population in excess of that indicated in DRCOG's allocation, they may be denied funds or the amount of their grant might be reduced. Thus, a difference in future population estimates is of importance both to local agencies and to DRCOG. In order to resolve remaining differences, a Cooperative Forecasting Program Task Force was established which included members of local jurisdictions and regional agencies. This group was charged with the development of a methodology and set of procedures for use in the preparation of local population forecasts, which would be applied both by DRCOG and the local agencies. This work was completed in March 1977.

Several of the proposed wastewater treatment porjects fall within areas whose future populations are in dispute. The Broomfield/Westminster area, for example, differs sharply with DRCOG on what the future population of the subregion will be: the local forecast for the two-city area is 135,350 (Broomfield, 62,000; Westminster, 73,300) while DRCOG's allocation is 103,400. The local forecast exceeds DRCOG's by about 24 percent. The same is true for the Lakewood urban service area (Reference 231). As the sanitary district boundaries do not correspond with the boundaries of urban service areas, the extent of disagreement between the local projections and the regional forecasts for the areas to be served by new wastewater facilities is difficult to determine.

Impact of wastewater facilities on land use--

Major investment in public facilities frequently serves to encourage growth, primarily by opening up land for development. The growth-shaping effects of sewers have been noted in a number of studies (References 1002 and 258) although most case study work has focused on interceptors rather than on wastewater treatment facilities. Such facilities influence an area's growth potential wherever new development is required to be sewered, which is the case in most areas of the Denver metropolitan region.

The lack of wastewater treatment capacity in any one area may limit growth for that area, but, viewed from a regional perspective, lack of service capacity in one area often diverts growth elsewhere. Growth will go where facilities are available to serve it, as a local building industry representative states (Wyckoff, personal communication, 28 December 1976).

Growth projections for the 201 facility planning areas are given in Table IV-I. The Littleton and Englewood planning area will experience nearly the highest growth rate and is projected to capture a full 24 percent of projected regional growth. Only the Lower South Platte area will experience a higher growth rate. See Map J for the location of those planning areas. Generally, all of the planning areas except for South Lakewood and South Adams County will each have a significant share of future regional growth.

Table IV-I. POPULATION GROWTH FORECASTS FOR FACILITY PLANNING AREAS

Facility Planning Area	Population, Thousands[a] 1975	1985	2000	Growth Rate 1975-1985	% of Total Regional Growth to 2000
South Adams County	27	29	29	Less than 1%	Less than 1%
Englewood and Littleton	141	217	344	4.4%	24%
South Lakewood	100	111	121	1.0%	2.5%
Cherry Creek and Goldsmith Gulch	259[b]	294[b]	370[b]	1.3%	13%
Lower South Platte	44	72	107	5.0%	7.5%
Clear Creek	198	246	305	2.2%	12.5%
Sand Creek	82	120	170	3.9%	10.5%
Westminster and Broomfield	55[b]	80[b]	113[b]	3.8%	7.0%
Planning Areas Total[c]	906	1,169	1,559	3.6%	77%

a. Based on facility plan projections except as noted, rounded to nearest thousand.

b. Based on DRCOG projections, facility plans based on DRCOG projections not complete.

c. MDSSD No. 1 includes Cherry Creek/Goldsmith Gulch, Clear and Sand Creek, and flows from Denver Northside plant and its inclusion would largely duplicate enumerated projects.

Viewing investments in public facilities as having a greater influence on the spatial distribution of growth than on the amount of growth suggests that decisions on whether or not to provide urban services should be viewed in terms of the chain of events they set in motion beyond the service are. Thus, a decision not to serve one area with expanded treatment capacity should take into consideration pressures on the treatment capacity and sewage systems in other areas.

CONVERSION OF AGRICULTURAL LANDS

The "conversion of agricultural land" is the name given to the process which results in a change in the use of land from agricultural to urban. This process may be direct and immediate: autumn's cornfield may be spring's subdivision; or it may be lengthy: orchards may be replaced gradually by row crops, and row crops by idle land, over a period of years before construction for urban uses begins. In the meantime, the land may have passed through several successive owners, from the active farm owner to a farm lessor to an owner/real estate investor to a developer. Whatever the length of time involved and the route taken, the outcome generally is the same: once farm land is converted to urban use, its reconversion to agricultural use is, under normal circumstances, impractical. This section discusses why conversion of agricultural land takes place and why this form of land use change is of environmental concern. It then addresses this issue in the Denver context and discusses historical and potential future conversion of agricultural land.

Causes of Agricultural Land Conversion

Farming is an economic activity. It supplies food and fiber products traded in local, national and international markets and provides a livelihood to farmers and farm workers. Obvious to those in the business of agriculture, this point must be made plain if we are to understand why land is taken out of agricultural use and what kinds of planning and institutional reforms would be needed to affect this process.

The farmer's principal raw material is land. Finding farm land at an acceptable cost is essential if a farmer is to stay in business. By "acceptable" is meant a cost at which the farmer makes a sufficient return to prevent him for diverting his assets to some other kind of investment. The farmer faces out-of-pocket costs for labor, fertilizers, pesticides, energy and taxes; he faces fixed costs relating to structures and equipment as well as to land. A prolonged period of negative net return will put the farmer out of business.

The value of the land is an important determinant of the feasibility of agricultural activity. In the first place, the purchase of land for agricultural use will take place only if the purchaser finds the price low enough to permit him to make a profit; land will be retained in farm ownership as long as its price does not exceed a level at which the return on investment in land falls below what capital invested elsewhere could earn. In the second place, land value (a fixed cost) affects property tax payments (an annual out-of-pocket cost). Rising costs of land therefore increase the costs of operating a farm as well as the costs of owning it. This can be a serious problem at the fringes of urbanized areas, where the value that accrues to land which satisfied the locational requirements of intensive urban uses is usually considerably higher than the income the land can generate in agricultural production. Land which would bring $500 per acre for farming use may command $2,000 per acre for urban uses.

While the farmer cannot influence the chages in the price of his land which arise from its value to others for nonagricultural uses, there are steps he can take to try to keep its agricultural value at or near its nonagricultural value. He can grow higher value crops and/or farm more intensively; in either case, the strategy would be to increase his net return, thereby maintaining a constant capital/output ratio. He can also simply hang on, hoping that rising agricultural product prices will compensate for rising land values. If these approaches are impractical, he (or eventually his heirs) will sell his land, either in small parcels over a period of time or as a block. [Particularly if the farm is advancing in years, the opportunity to sell off small parcels for urban development may provide income for retirement; this is one of the reasons why farmers may object to restrictions on farm land conversions, as is reported to be the case in eastern Adams and Arapahoe counties (Paul, personal communication).]

The following discussion of agricultural land use, conversion trends and the effects of the current drought on both is not a prediction of what will be happening in the near future in the Denver region. Rather, it is a discussion which reflects on some of the plausible consequences to agricultural and urban land use patterns should the drought continue beyond this precipitation year. It is by no means comprehensive of all the possible socio-economic effects of which the drought might be a factor.

The current drought could accelerate existing trends to discontinue agricultural activities as greater areas of farmland become marginal due to a lack of adequate precipitation. Drought conditions intensify competition for available supplies of water. The farmer, faced with reduced precipitation, compensates by increased irrigation or by growing crops requiring less water. The latter course is limited because high value crops generally require greater amounts of water. Also, the prices farmers have been getting the last few years have often not covered production costs. Thus lower value crops are even less attractive. Drought conditions also affect municipal and industrial water supplies. With these competing demands, the farmer most often loses even if he or the canal company hold senior water rights. This is because municipalities can institute condemnation proceedings to convert agricultural water rights to municipal uses. The cities of Westminster and Thornton are now involved in such proceedings. Municipal water demand is somewhat more flexible than agricultural demand. The farmer has less flexibility in the amount of water he requires given climate and the crops he must grow to receive an adequate return. Municipal and to a lesser extent industrial water users can reduce their use significantly without significant changes in lifestyle or operations. Little advantage has been taken in the Denver region of these differences in water demand flexibility. Consequently, urban growth and drought conditions, coupled with low or nonexistent returns from farming have placed the agricultural sector under severe pressure. Because few farmers can afford to retain their lands in fallow for very long, many of them could be forced by financial considerations to sell out.

In a situation such as this, in which neighboring farmers are not likely to be in a position to acquire more land, a "buyers market" can develop for corporate agriculture interests and land speculators. Whenever there is potential for a change in the type of land tenancy, such as in this case, in which lands could change from family farms to corporate farms and speculative land developments, there is also potential for a change in the agricultural economy of the region.

The agricultural capacilities of lands purchased by agricultural corporations would not likely be changed. However, the family farm sector of the region's agricultural economy would be further reduced by some degree. This is a great concern to many of Colorado's family farmers (Reference 977).

In contrast, the agricultural capacilities of farmlands purchased by land speculators are quite likely to be affected. Land speculators operate under financial pressures resulting from substantial interest payments on mortgage notes and from a lack of production income and investment dividends. A common strategy used to realize a return on a rural land speculation is to minimize the time the land is held by the speculator. Under this strategy the speculator subdivides the property into the maximum number of parcels local land use regulations and his financial resources will allow. He then makes whatever minimum improvements are required and sells the parcels as small farms and "ranchettes." The effect of these smaller parcels is to diminish or eliminate the capability to continue the large scale agricultural operations that were possible prior to subdivision. Although many smaller scale agricultural activities are not precluded and some are actually made feasible by the smaller parcel sizes, it is impossible to predict the utilization plans of a diverse group of new land owners. While some new owners may invest capital and labor into intense agricultural activities such as truck farming, others may desire only to raise a portion of their own food and keep a few animals. It is all too common, however, for a new owner to himself be a speculator who will not use the land productively but will attempt to divide it further.

This type of speculative activity generally occurs just outside the urbanizing fringe, where local jurisdictions are unwilling to grant entitlements for dense, urban development. Despite these efforts to control "leap-frog" development, the newly diminished, large-scale agricultural capabilities and fragmented ownership patterns of relatively small parcels near the existing urban fringe establish many of the requisite conditions for leap-frogging. Once dense development is introduced into such an area, thereby establishing a precedent for further development, the urbanizing fringe is extended further into the region's agricultural hinterlands. This process occurs with or without drought conditions, of course. As stated at the beginning of this discussion, the factor contributed by the drought is a stimulation of the rate at which the process operates, so that farmlands are converted before the urban region has a well-defined need for them.

To summarize, there is land value maximum beyond which it becomes uneconomic to farm. After this point is reached, the land may still remain in production for a time as ownership changes from the farmer to a nonagricultural corporation or landowner who leases it back to the farmer. However, the point at which continuation of agricultural use can be assured has by then been passed, and it becomes increasingly certain thatthe land will be urbanized. Farm ownership patterns are a good index of how far the process has gone. In California coastal counties still responsible for much of that state's agricultural production, the number of farm-owner-operators has fallen sharply since the 1950's; in San Mateo County, south of San Francisco - a major center for production of brussel sprouts and other vegetable crops - over three-fourths of the agricultural land remaining in 1970 was already operated under leasehold arrangement (Reference 989). Conversion to urban uses under such circumstances becomes a matter only of time.

Agricultural Land Conversion as an Environmental Issue

The competition between agricultural and urban uses is often intense because both uses can frequently be provided most efficiently on the same type of land. Urban uses and most crops can be produced most economically on land with slight to moderate slopes, good drainage, relatively little waste area and good water availability. Concern about loss of agricultural land may arise from a socio-economic perspective or from an ecological perspective, or from both.

Socio-economic impacts of agricultural land conversion--

As the present century has progressed, the United States has become increasingly important in the international economy as a food (especially grain) exporter. Maintenance of food production both for domestic use and for export is a major concern of some observers, who fear that continued conversion of agricultural lands may ultimately cause a domestic food shortage, resulting in an international shortage: "There has been an overwhelming excess of potentially arable land for all of history, and now, within 30 years (or about one population-doubling time), there may be a sudden and serious shortage" (Reference 998).

While this concern may have a theoretical validity, there seems to be no real danger that the overall national supply situation will be adversely affected in the foreseeable future by agricultural land conversion. In the period since Worl War II, both Canada and the Untied States have witnessed a considerable increase in urbanized lands, but at the same time North American grain exports increased dramatically, from 23 million tons in 1950 to 56 million in 1970 (Reference 983). This has been possible because of significant productivity increases in both farm land and farm labor. Between 1931 and 1965, per acre wheat yield more than doubled, from 13 to 27 bushels per acre; corn production per acre more than tripled, from 23 to 73 bushels per acre (Reference 990). At the same time, the farm population fell from 30 percent to less than 5 percent of the total population (Reference 998). Given the overall decline in cropland forecast to take place by the end of the century, the U.S. Department of Agriculture nevertheless finds that the nation's cropland resources can more than supply domestic and export needs (Reference 720).

However, while the future supply may be adequate, the cost may rise. Over most of the past 45 years, the percentage of disposable income Americans spend on food has declined. This trend has recently been reversed: in 1972, 15¢ of each take-home dollar was spent on food, but in 1974 that figure had rise to 17¢. This change is cause for concern because lower income families may have food costs per-dollar-earned that are double or triple the national average. Rising food costs are, in part, a land use problem: "Part of the rise in food costs can be traced to higher input costs, expecially land and structural imbalances in farm units found in mixed land use areas" (Reference 992). In the Denver region and in Colorado generally the cost and availability of water are added problems affecting the economic viability of agriculture.

Farmers need farmers for neighbors. Farm practices and operations tend to conflict with urban uses. Expansion of farm size becomes difficult where farming is at the urban fringe, and farm expansion may be necessary to permit the application of new technology to increase productivity. Average farm size nationally increased almost 30 percent between 1959 and 1969 (Reference 996). The evolution of a land use pattern that intersperses actual and potential urban uses with agricultural uses is inefficient and costly both to food producer and consumer. The situation of agriculture as a local land use is therefore a legitmate environmental concern.

Impacts of agricultural land conversion on the natural environment--

Preservation of land in agricultural use results in a number of benefits. Generally, the effect on air is positive since any green cover contributes to oxygen supplies. However, if drought and/or economic conditions result in significant areas laying fallow, wind erosion and particulate air quality problems will result. Agriculture may use significant supplies of fresh water, but some ground water recharge takes place. While farm runoff can be a problem, farmers try to minimize soil erosion. Farming also presents a generally attractive landscape, representing a minimal departure from the "natural state" of the environment. Finally, urban land uses which replace farming would typically have more adverse impacts on the natural environment associated with them.

Agricultural land conversion is part of an overall assessment of land use change which is to be addressed in environmental impact statements. Farmlands classified as "prime" or "unique" are subject to specific consideration udner current federal and regional policies. The U.S. Council on Environmental Quality has stated that "efforts should be made to assure that such farmlands are not irreversibly converted to other uses unless other national interests override the importance of preservation or otherwise outweight the environmental benefits derived from their protection" (Reference 103). The benefits cited include provision of open space, scenery and wildlife habitat; it is also pointed out that prime lands by their nature produce more food with less erosion and lower fertilizer and energy requirements. Policy of the Denver Regional Council of Governments calls for discouraging new development in these areas. (Reference 204).

Conversion of Agricultural Land in the Denver Region

In the period between 1960 and 1970, land devoted to urban uses in the Denver region increased by 12.3 percent while land devoted to agriculture declined by 6.8 percent. In all, about 33,600 acres were lost to agricultural production, while 41,700 were added to urbanized areas. Most new urban land come out of the agricultural category, though some came out of vacant and public use categories. The decline in agricultrual use affected every county, as Table IV-J. shows. How much of this loss was prime agricultural land is not known.

TABLE IV-J. AGRICULTURAL LAND USE IN THE FIVE-COUNTY REGION: 1960, 1970 (1,000 acres)

County[a]	Year	Total Acres	Developed	Undeveloped Agricultural	Vacant
Adams	1960	243.0	36.9	189.5	16.6
	1970		46.0	177.2	19.8
Arapahoe	1960	126.8	33.2	80.2	13.4
	1970		36.7	74.9	15.2
Boulder	1960	282.9	64.5	139.0	79.4
	1970		72.6	133.9	76.4
Denver[b]	1960	63.4	46.9	7.4	9.1
	1970		52.6	2.0	8.8
Jefferson	1960	498.2	158.6	76.9	262.7
	1970		174.0	71.3	252.9
Total[b]	1960	1214.3	340.1	492.9	381.3
	1970		381.7	459.4	373.2

[a] Excludes eastern Adams and Arapahoe Counties and western Boulder County.
[b] Detail may not added to total due to rounding.
Source: Gruen Gruen + Associates based on Reference 205.

The forces affecting agricultural activity which were described in the preceding pages will continue to influence land development patterns in the Denver region through the end of the century. No forecast of agricultural land conversion was found in the course of our research; however, it is possible to project conversion of agricultural land to urban land based on existing trends as a way of estimating the magnitude of change which can reasonably be expected if a year 2000 population of 2.35 million is attained.

Three approaches were used in making this projection. The first was to extrapolate existing trends. The second was to calculate the loss in agricultural acreage associated with each added unit of population in the 1960-1970 period and to assume the same association will pertain through the year 2000. The third was to measure the acreage of prime soils lost from maps of future land use. Only the Denver urban region was considered; eastern Adams and Arapahoe and western Boulder Counties were excluded, as these areas are not expected to experience urbanization.

As Table IV-K indicates, agricultural acreage in the year 2000 would be between 325,000 and 359,000 acres, depending on the trend line being considered. In the former case, a reduction of 29 percent (134,100 acres) in agricultural land is projected; in the latter case, a reduction of 22 percent (100,800 acres) is projected. Note that the coefficient of conversion (acres converted per person added to the population) rises the more urbanized the area. This is because in densely settled areas (such as Denver County) land development tends to have a larger complement of nonresidential uses, while in sparsely settled areas (such as Jefferson County) new development is primarily residential.

The projections of agricultural land presented in Table IV-K are trend projections based on the conversion experience of the decade between 1960 and 1970. As is the case with any projection based on past trends, there is an implicit assumption that the conditions which applied in the historic period (1960-1970 in this case) would also apply in the future. This assumption may not be valid. The supply of agricultural land in 1970 differs in location and type from the 1960 supply, and the spatial distribution of urban growth between 1970 and 2000 is not expected to resemble the 1960-1970 pattern. Thus, the projected totals may be reasonable, but the distribution by county may be somewhat different. DRCOG, as shown in Table IV-F indicates that the total land in agricultural, undevelopable, and other vacant categories would be about 336,000 acres. As this grouping includes additional land use categories, the total may be considered an upper limit. Thus the 325,000 acre projection in Table IV-K appears more reasonable. The conversion of 134,000 acres represents a 29 percent reduction in agricultural land.

A comparison of future land use patterns with the distribution of prime agricultural soils reveals the extent of possible loss of existing and potentially productive prime agricultural land to urban expansion. This comparison assumes that the prime agricultural soils, as shown on Map D, are a limited irreplaceable resource and the future land use patterns as defined by DRCOG, see Map I, will in fact materialize. The results of the comparison are shown in Table IV-L. It

TABLE IV-K. PROJECTED YEAR-2000 AGRICULTURAL LAND IN THE FIVE-COUNTY REGION[a] (1,000 acres)

	Adams	Arapahoe	Boulder	Denver	Jefferson	Total
Year 1970[b]	177.2	74.9	133.9	2.0	71.3	459.4
Year 2000 based on extrapolation of 1960 to 1970 trend[d]	135.0	57.0	114.1	none	53.6	358.6
Year 2000 based on per capita agricultural land conversion from 1960 to 1970[d]	129.5	46.0	106.8	none	43.0	325.3
Coefficient of conversion	0.1885[e]	0.0906[e]	0.0947	0.5208	0.0552	0.1168

[a] Excludes eastern Adams and Arapahoe and western Boulder Counties.

[b] From Table II-F.

[c] County projections have been proportionally adjusted to sum to totals.

[d] One study (Ref. 719) reporting on Adams and Arapahoe Counties found a coefficient of conversion for cropland of 0.148 for the two-county area. Figures in this table cover land in all agricultural uses, not just cropland.

Source: Gruen Gruen + Associates based on Table IV-F and Refs. 205 and 262.

is estimated that no more than 5,000 acres of prime agricultural soils would be lost in Jefferson County for a total loss in the region of about 38,000 acres. This represents about 23 percent of the prime agricultural soils in the region.

TABLE IV-L. ANTICIPATED CONVERSION OF PRIME AGRICULTURAL LAND AS A CONSEQUENCE OF URBAN EXPANSION TO TO YEAR 2000

County	Number of acres expected to be urbanized
Adams	20,000
Arapahoe	8,000
Boulder	5,000
Denver	Insufficient data
Douglas	400
Jefferson	No published data
Weld	No published data

These sharp declines in agricultural land use in the five-county area represent only part of the likely future state of agricultural activity in the region. As the agricultural lands on the fringe of the Denver urbanized area are gradually converted to urban use, there will be increased pressure to expand and intensify agricultural activity in areas just beyond the metropolitan region. These pressures would be felt most strongly in eastern Adams and Arapahoe counties, southern Weld County and northern Douglas County. If supplies of water for agricultural use permitted, increased agricultural production in those areas would take place, with little loss in overall production despite urbanization of some cropland. However, water is a far more important constraint on agricultural activity than is land in this region, and local agricultural experts report that urbanization threatens continued agricultural activity, less because it absorbs agricultural land than because domestic water users have priority over agricultural users in the allocation of water. The condemnation of water rights may make farming economically infeasible long before pressures for conversion of agricultural land are experienced.

AIR QUALITY IMPACTS

Introduction

For several years, it has been presumed that acceptable air quality in Denver was one of the main limiting factors for future growth in Denver. The "carrying capacity" of the Denver airshed appears already to be exceeded, given current frequent violations of air quality standards. It was then anticipated that planned growth, which required the support of wastewater treatment facilities, would add to the problem and lead to unacceptable air quality in Denver from the present to the year 2000. This was expected to be true in spite of adoption of a Denver Transportation Control Plan which specified measures which might be taken to improve air quality. For this reason, the analysis of air quality was performed for this EIS to investigate the probable future impacts and potential mitigating measures. This analysis was performed by Systems Applications Incorporated under contract to EPA. A report of this work is available upon request and is listed in the Bibliography as reference 998.

A major goal of the Denver study was to predict the effect of land use and population forecasts used in planning the eight proposed wastewater treatment facility plans (201) and the Clean Water Plan (208) on future Denver (1985 and 2000) air quality. In order to assess the relative impacts of such actions, air quality was modeled for future years for various pollutants to attempt to estimate the air quality consequences of future growth.

Since urban growth and development and the attendant increase of pollutant emissions depend on factors in addition to the availability of sewage systems, and in particular, since urban development depends on decisions not yet made, predictions of future growth are not simulations of complete certainty. The analysis of Denver's future air quality has become an exercise in hypothesis. The question is not so much "What will Denver's air quality be? but rather, "What will Denver's air quality be if...?". There is no single unique analysis of future air quality. The variation of air quality with changes in assumptions is an important aspect of the analysis, but to define these changes, there must be an initial condition from which to measure departure.

The initial or base condition of Denver's air quality for future years under study, 1985 and 2000, is taken to be the state which would most probably be realized. In this case, it means the air quality impacts from emissions which do not strictly meet federally mandated levels for automobiles and future growth.

Since plans and projections for Denver's future have been formulated, examined and accepted in the absence of this air quality analysis, those plans become the "base" for assessing probable future air quality impacts. Variations from this base case for future years are evaluated in the section on mitigating measures.

Modeling Air Quality in Denver

The Denver Air Quality Model (DAQM, reference 998) was utilized to predict ozone concentration. Modeling of photochemical oxidants is exceedingly complex. The major oxidant of concern, ozone, is not generally emitted from man-controlled sources. Significant background concentrations of ozone from natural sources can and do occur. It is generally believed, however, that critical ozone concentrations in urban airsheds are produced by chemical reactions in the atmosphere between atmospheric oxygen, nitrogen oxides, gaseous hydrocarbons, and other less significant compounds. The primary sources of nitrogen oxides and hydrocarbons in the urban atmosphere are combustion machines, most importantly, motor vehicle engines.

The primary nitrogen oxide species emitted is nitric oxide (NO). In the presence of large amounts of NO (relative to NO_2 quantities), it typically takes from one to several hours for the NO_2/NO ratio to become high enough for significant ozone to form. In such a time period, precursor materials are likely to blow far from their sources and become significantly dispersed. For this reason, ozone concentrations are likely to be quite sensitive to wind patterns and atmospheric mixing. Nonreactive pollutant concentrations are often more clearly related to wind speed, direction and stability near their source, than to regional wind patterns, since they become quite diluted for long dispersion times. (Note: This is true of ozone precursors also, but since little ozone is formed very near the sources, high ozone concentrations are not expected there.)

Models which do not take account of wind patterns are not expected to predict ozone patterns well; therefore, in this study, a grid based physio-chemical model was used for the analysis of regional photochemical oxidant.

Particulates and NO_2 were analyzed with the Gaussian Climatological Dispersion Model (CDM); however, it is very important to note that most NO_2 in an urban atmosphere is not emitted, but is a product of photochemical reactions just as is ozone. Thus, CDM, which does not include chemistry algorithms, assumes all emitted NO to be equivalent to NO_2. This is probably valid for far downwind locations, but is clearly not even approximately true at the times and places for which maximum NO_2 concentrations are computed with CDM. Therefore, the reactive model DAQM was also run to predict hourly NO_2 concentrations for the years 1974, 1985 and 2000. Annual average NO_2 concentrations were then inferred from the DAQM results. See Reference 998.

Carbon Monoxide (CO) is inert and does not react in the atmosphere. As a result, carbon monoxide concentrations are generally highest near the source (e.g., from automobiles, the highest concentrations occur along the roadway and intersections). A grid model does not estimate "local hot spct" areas but rather calculates averages within the area of the grid. However, for a regional scale analysis, a grid model is useful for obtaining trends and regional large scale CO concentrations. For the regional scale analysis, the DAQM grid model was utilized to evaluate future CO levels.

Information on further localized "hot spot" CO concentrations was taken from the I-470 air quality impact study performed by the Colorado Division of Highways (CDH). In these calculations, CDH used the California Line Source Model to evaluate the microscale CO effects.

Data and Assumptions

For the purposes of evaluating and modeling present and future air quality in the Denver Metropolitan Area, a number of emission files of estimated present and future emissions of various air pollutants were provided by the Air Pollution Control Division of the Colorado Department of Health and by the California Division of Highways.

In general, highway and nonhighway traffic account for a major fraction of most of the pollutants emitted. While automobiles and other vehicles do not directly contribute to the particulate problem, a large percentage of the particulate matter results from materials on streets thrown up by vehicles (45 to 60 percent of the total particulate emissions). Point sources contribute the next largest percentage of emissions and these sources account for as much as 50 percent of the total NO_x emissions as well.

The emissions which were utilized in the DAQM validation for the days in 1975 and 1976, consisted of reactive hydrocarbon and nitrogen oxide emissions to determine photochemical oxidant concentrations. To determine CO concentrations, estimates of these emissions were also input into the DAQM model.

Future emissions were estimated with emission factors based on recent auto emission test results. These emission estimates are higher than the current and optimistic EPA vehicle emission factors from AP-42 Supplement #5 for 1985 and 2000. This approach was used because recent auto emission tests demonstrate an inability to achieve the required emission reductions in new cars and the inadequacy of emission control system maintenance.

Point sources were projected to the years 1985 to 2000 by assuming that increases in emissions were directly proportional to increases in area of industrially-zoned land. Future zoning changes were determined from various land use plans and population projection forecasts. Space heating and other area-wide emissions were computed based on population forecasts and projected land use allocations.

The emissions that were used in predicting 1985 air quality are presented in Table IV-M. Emissions were estimated in the summer and winter months and revealed the following:

1. Winter emissions exceeded summer emission for all three pollutants (reactive hydrocarbons, nitric oxides, and carbon monoxides). This was due to an increase in auto emissions in the winter. The most significant differences were obtained from carbon monoxide emissions.
2. Automotive emissions of carbon monoxide, hydrocarbons and NO_x are higher than Supplement 5 estimates because of the lack of proper maintenance of emission control systems, the failure of emission controls equipment, and the apparent inability to achieve the required reduction of certain pollutants for new cars.
3. Point sources contribute almost 20 percent of the reactive hydrocarbon emissions and about 10 percent of the carbon monoxide emissions.

Table IV-M. Denver Emissions Inventory (tons per day) for 1985 Air Quality Projections

Season	Reactive HC	NO_x	CO	Particulates
Winter	220.5	346.0	3,715	130
Summer	154.2	310.8	1,776	130
TOTAL	374.7	656.8	5,491	260

Source: Systems Applications, Inc.

Emissions utilized to project year 2000 air quality levels are presented in Table IV-N. Emissions for this year were calculated on a summer and winter basis for different source categories. An examination of this table reveals the following:

1. Winter emissions exceed summer emissions for all three pollutants (hydrocarbons, nitrogen oxides, and carbon monoxide).

2. Emission of carbon monoxide and nitrogen oxides decrease from 1985 but hdrocarbons are predicted to increase over 1985 levels. The hydrocarbon increase is due primarily to increases in traffic, difficulty in achieving the required emission levels, a failure of emission control devices and/or lack of proper maintenance programs.

Table IV-N. Denver Emissions Inventory (tons per day) for 2000 Air Quality Projections

Season	Reactive HC	NO_x	CO	Particulates
Winter	180.6	327.2	2,370	158
Summer	124.4	276.9	1,266	158
TOTAL	304.0	604.1	3,636	316

Source: Systems Applications, Inc.

Model Validation--

Ozone Validation

The Denver Air Quality Model (DAQM) was validated for ozone on summer days, 29 July 1975, 28 July 1976, and 3 August 1976; since these were the only days for which meteorological data were available, and for which sufficient air quality data were available with which to compare the simulation results. The 1975 day did not approximate a worst day for 1975, but significant violation (11 pphm) of the ozone standard (8 pphm) was observed. The second (18 pphm) and third (16 pphm) highest ozone observations of 1976 were on the two days of that year simulated. The two 1976 summer days were subsequently used with future emissions to predict 1985 and 2000 air quality.

The simulation for 28 July 1976 yielded a peak computed ozone level at any monitoring station of 16 pphm, the same value as was actually measured. However, the peak ozone level computed for that day occurred elsewhere in the region, and was 22 pphm. The simulation for 3 August 1976, computed a station peak level of 15 pphm. The observed value was 17 pphm. Again, the peak computed anywhere in the region was higher than any observed value, namely 24 pphm. Therefore, there is no assurance that current monitoring stations are recording the peak ozone levels occurring in the region, or that they will do so in the future.

Nearly 300 comparisons were made between hourly-average concentrations computed for grid cells, and concentrations observed in the atmosphere at corresponding points. These comparisons are presented and discussed in Reference 998. Although there were substantial differences between computed and observed concentrations on some occasions, on the whole, impressive correspondence between them was noted. The differences were not so large as to distinguish between simulation and observational error. Therefore, the simulation errors are only bounded by the noted differences. It is likely that much of the difference is due to observational error.

The plots in Figure IV-C show differences between computations and observations averaged over time at stations, over stations at each hour over both time and place for each simulation day and for all days. The averages were examined for evidence of regularities that would suggest correctable error in the formulation of the model. Computed results did average lower than observations early in the morning and late in the afternoon. Generally, the model predictions compared very well with observations.

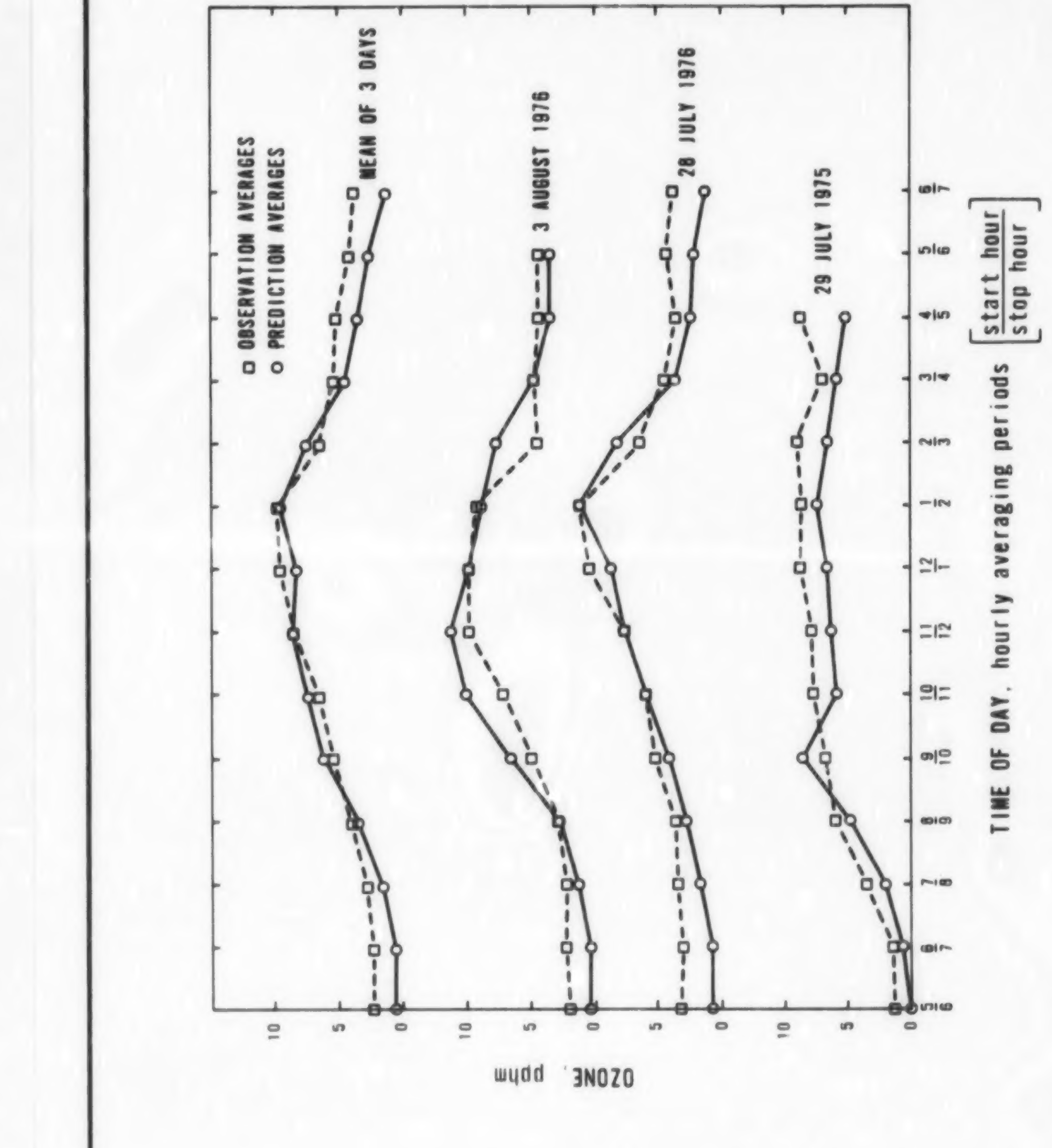
Carbon Monoxide Validation--

The carbon monoxide validation actually did not produce as favorable results as did the DAQM ozone model. At certain monitoring locations for some of the simulated days, good agreement between simulated and observed concentrations was found. In other cases, substantial differences exist between observations and simulated concentrations. In part, this is due to the nature of the computer model used. The model simulates average CO concentrations over a four square mile grid cell, whereas air quality monitoring stations sample air at a single point. Therefore, the model predicts regional scale CO concentrations while monitoring stations are greatly influenced by very local CO emissions from nearby road and traffic intersections.

NO_x Validation--

Available NO_2 information was totally inadequate for validation of the models for these species. Since the Climatological Dispersion Model (CDM) was not used in this study for drawing

FIGURE IV-C



THE VARIATION OF AVERAGES OVER ALL STATIONS OF OBSERVATIONS AND PREDICTIONS inferences relative to future NO_x levels, no attempt was made to validate CDM for purposes of NO_2 prediction. The inferences drawn for NO/NO_2 probable impacts and mitigations have not been scientifically validated and merely represent best estimate.

Particulate Validation--

The CDM was used to predict particulate concentrations and was previously calibrated by the Colorado Department of Highways. Background levels and the calibration coefficients previously determined were utilized for the CDM runs in the Denver study and no attempt was made to validate the background or calibration coefficients.

Denver Air Quality Projections

Estimates of present and future air quality in the Denver region were made from model computations using the Denver Air Quality Model (DAQM) and the Climatological Dispersion Model (CDM). Computations were made for comparison with each National Ambient Air Quality Standard (NAAQS). The DAQM, a "real time" model was used to estimate the highest occurring hourly average concentrations of ozone, carbon monoxide, and nitrogen dioxide. The DAQM results were used to make inferences regarding potential violations of the annual average NO_2 standard. A much more complete description of the air quality modeling efforts discussed here can be found in reference 998.

Ozone--

As described previously, two of the three summer days for which data were available were reasonably representative of worst case ozone episodes. Results of future simulations using meteorological data from these days and compared with 1976 simulation results show that peak ozone concentrations are predicted to drop from 24 parts per hundred million (pphm) in 1976 to 15 pphm in 1985 and 11 pphm in 2000. For each of these years, the predicted ozone concentrations exceed the standard of 8 pphm.

Results of the model simulations also showed decreases in the area extent of violation over time. In 1976, the area computed as exceeding the ozone standard covered a maximum of 300 to 400 square miles at any one hour. By 1985, the computations show only about 132-184 square miles in violation of the standard. By 2000 the area is reduced to 24 to 40 square miles.

Carbon Monoxide--

Carbon monoxide concentrations were computed with DAQM for a bad (poor dispersion) winter day in November 1974. Winter days in the Denver Metropolitan Area tend to be most crucial for nonreactive pollutants, since the low solar intensity and low wind speeds permit the shallow morning mixing layer to last longer and sunlight is not required for production of the nonreactive pollutants.

The concentration gradients of nonreactive pollutants can be much larger than for ozone. This is because peaks occur very close to the sources (primarily traffic for CO) before dispersion dilutes the pollutant material. As a result, the definition of peak concentrations of CO is very difficult. CO monitors on opposite sides of a heavily travelled street can easily show concentrations differing by a factor of two or even an order of magnitude. The DAQM computation has a 2-mile resolution and, therefore, the microscale street effects would be suppressed.

Under present conditions, CO violations can surely be found in any major urban area at particularly critical spots such as industrial, shopping centers or stadium parking lots or at busy intersections. This is known to be true for Denver. The DAQM predicted on a regional scale, that the average CO concentration over an 8-hour period was 16 parts per million (ppm) for 1985, and 5 ppm for 2000. The 8-hour standard is 9 ppm. Therefore, on a regional scale, CO concentrations will exceed the standard for 1985, but be below the standard by 2000.

A 1985 and 2000 microscale analysis utilizing the California Line Source Model was conducted by the Colorado Division of Highways to evaluate the microscale effects for its proposed I-470 alternatives. Analyses of the modeling results indicates that the highest level of CO for the years 1985 and 2000 will be experienced along the Santa Fe Drive.

The data computed for sensitive receptor areas indicates that concentrations will exceed the standard for the worst meteorological case. Furthermore, the standard was predicted to be exceeded in the Cinderella City area in 1985 and is exceeded for most traffic concentrations in year 2000. Since the result of these analyses were based on current, yet optimistic emission factors, it is probable that these results are low. Also, calculations in this analysis were made on a one-hour basis and it would be expected that many 8-hour "hot spots" violations would occur in 1985 and 2000, since the 8-hour air quality standard is more often exceeded than the one-hour standard.

Nitrogen Dioxide--

Estimates of long-term nitrogen dioxide (NO_2) concentrations are difficult to determine. The primary emitted species is NO. After entering the atmosphere, NO is typically oxidized to NO_2 in the same complex photochemical reaction that generates ozone. Because NO eventually becomes NO_2, the typical standard violation analysis computes, not NO_2, but NO_x concentrations assuming all NO_x emissions are NO_2. Since an annual average is desired (the standard for NO_2 is annual average), NO_x modeling is usually done with EPA Climatological Dispersion Model (CDM) or other annual Climatological models.

While all NO may eventually oxidize to NO_2, all emitted NO is clearly not NO_2 at all positions along its downwind path. NO_x is particularly not NO_2 while it is still near its source where it is densest. CDM can therefore be expected to seriously overestimate NO_2 in the denest source areas of a region. CDM estimates should be more accurate near the periphery of the modeling region.

CDM is a calibrated model; that is, its results are multiplied by a factor to make them correlate with observed conditions. The Denver region has had just one NO_2 monitoring station which is the center of the downtown NO_x source area. CDM results were calibrated with data from this station and they should be equivalent to the observation at that site for the calibration year. The results from CDM should be progressively more in error (underpredicting) with distance from the calibration site. Since the emissions of all interacting species change differently years into the future, the calibration should not be valid for future years.

The problem of the complex photochemical reactions for NO_2 formation could be resolved by using DAQM; in fact, NO and NO_2 concentrations are computed by DAQM. Use of this model does not, however, give annual averages and therefore direct comparisons with the NO_2 standard cannot be made. Peak NO_2 hourly average concentrations computed with DAQM for worst case summer days show decreases in NO_2 from 1976 to 1985 and again to 2000. This is in contrast to predictions of steady increases of NO_2 using the erroneous assumptions of CDM. The conclusions that may be drawn are:

1. Observations show current compliance with the NAAQS standard of 5 pphm NO_2 on an annual basis, however, the one station recording NO_2 concentrations may not be located in an area of high concentration.

2. Annual average NO_2 concentrations may not increase in future years. They may decrease somewhat.

Particulates--

Annual average particulate concentrations were computed with CDM. The model results were calibrated with observational data. The predicted concentrations are so high (four to five times the State standard) that current and future violations are expected. The NAAQS for particulates was predicted to be exceeded over 460 square miles in 1974, 548 square miles in 1980, 688 square miles in 1985, 716 square miles in 1990, and 724 square miles in 2000. Figure IV-D shows the average annual particulate concentration projections for various areas around the Denver Metropolitan Area.

A summary of the results of the analysis of future Denver region air quality is presented in Table IV-0.

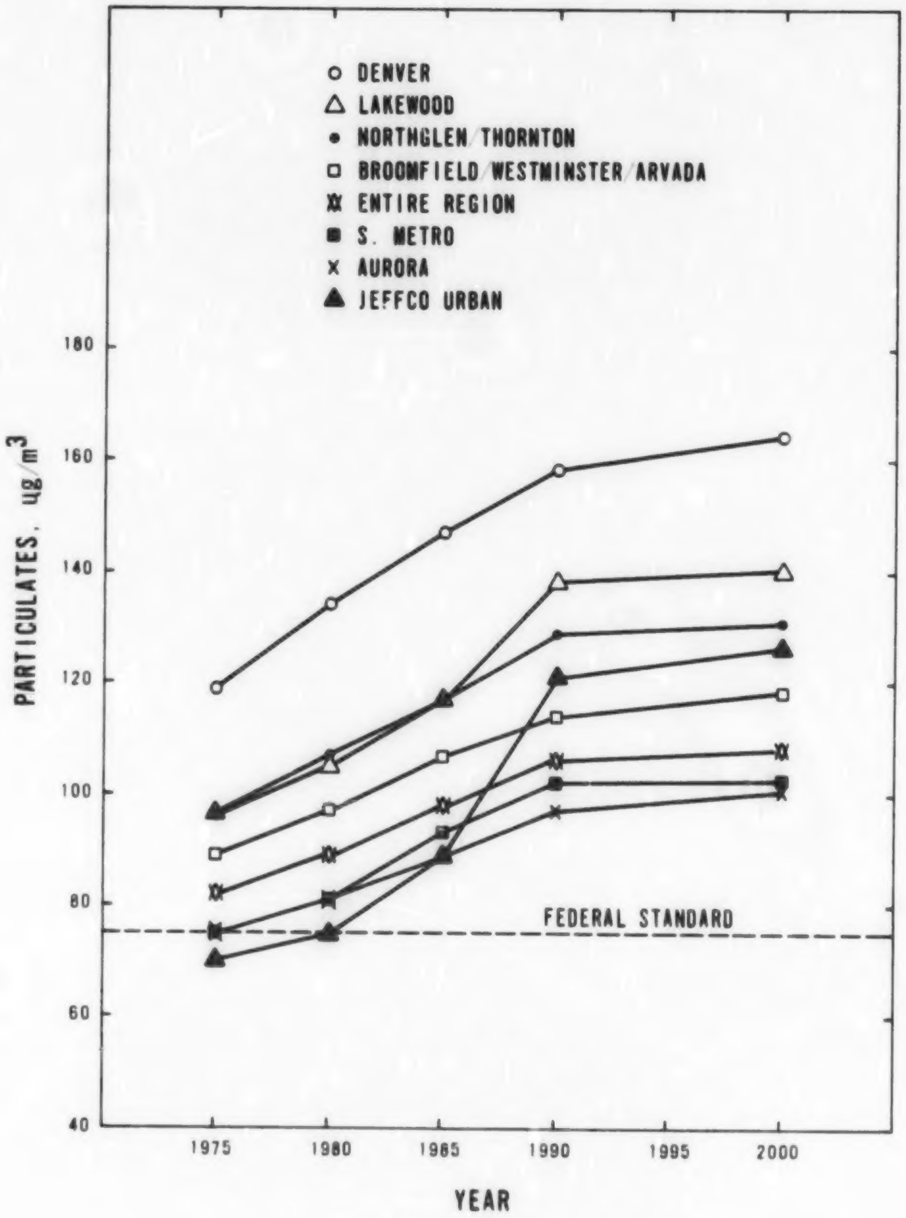
Uncertainty of Results

Air quality impacts previously discussed assume that emissions for future automobile model years will be higher than required by the Federal Emissions Control Program. This assumption is based on the present experience indicating that a fraction of vehicles experience early catalyst failure, another fraction have engine maladjustments, and the remaining fraction are properly tuned vehicles with operating catalyst. It is also assumed that as a model year becomes older, more vehicles experience catalyst failure and become maladjusted. If these fractions are all taken into account, it results in limited success of the emissions control program. Any significant variance from these assumptions could result in different results as explained in the discussion of effectiveness a vehicle inspection and maintenance program in the section on Mitigation Measures for Air Quality.

The vehicle emissions used in this analysis also assume some delay in the required implementation date for emission control limitation. It is assumed that the implementation dates for carbon monoxide and hydrocarbon standards of 3.4 grams per mile and 0.41 grams per mile, respectively, will be delayed one year from 1978 to the year 1979. Required implementation date for the NO_x standard was assumed to be delayed until 1981. The presently required date is 1978. Due to the apparent inability of the auto manufacturers to constantly meet the present standard requirement, these assumed set backs may be conservative.

The modeling of ozone and carbon monoxide utilized meteorological data from two summer days in 1976 and one winter day of 1974, respectively. Therefore, as a result, assumed future

FIGURE IV-D



AVERAGE PROJECTED PARTICULATE CONCENTRATIONS 1974 TO 2000

Table IV-0. DENVER AIR QUALITY PROJECTIONS

Model	Pollutant	Federal standard	State standard	Computed maxima 1976	Computed maxima 1985	Computed maxima 2000	Area of exceedance (mi^2) 1976	Area of exceedance (mi^2) 1985	Area of exceedance (mi^2) 2000
DAQM	Ozone	8 pphm 1-hr.		24	15	1	300-400	132-184	24-48
DAQM	CO	35 ppm 1-hr		26	27	6	*	*	*
	CO	9 ppm 8-hr.		15	16	5	*	*	*
DAQM***	NO_2	82 μg/m^3 annual average		79	75	74	*	*	*
CDM	Part.	75 μg/m^3 annual average	45 μg/m^3 annual average	168	217	229	460	688	724

*Not calculated

**Observed Value

***Annual averages determined from peak hour values based on proportionality between observed values. See Reference 998.

meteorological conditions are identical to those that occurred on these days. Although it is assumed these days are representative, and to some degree typical, of higher ozone and CO pollution episodes, meteorological conditions will vary from year to year. For this reason the sensitivity analysis was performed for ozone to determine the variability of results obtained to changes in the meteorological assumptions. Lower average windspeed and shallower average mixing layers than were originally estimated from the data were investigated. Specifically, a 1/3 decrease in windspeed and in mixing layer of thickness was assumed separately and together. The decreases were proportionate in every grid point, thus all wind patterns were preserved. Results of these model simulations showed that a 1/3 change in windspeed increased the peak ozone concentration by only 1 pphm but increased the total area subject to standard violations by 80 square miles. Nearly the opposite was the case for the 1/3 lowering of the mixing layer thickness, with peak ozone concentration increasing by 4 pphm, but the area of violations increasing only by 30 square miles. Both meteorological parameters would change peak ozone concentrations by much more than the sum of the individual effects. For 1/3 decrease in both windspeed and mixing layer thickness, peak ozone concentration increased by 8 pphm and the area of standard increased by approximately 100 square miles. It appears that the assumed meteorological estimates would have to be in error by a substantial amount in order to invalidate the previous ozone results.

For the meteorological conditions evaluated, it is assumed that there is no carry over of pollutants from one day to the next, nor any reentry of pollutants during a single day after they have left the modeling area. In Denver, the afternoon mixing layer is typically quite deep, as compared with morning conditions. This, together with the lack of any topographic barrier on the east and north, which are both downhill and down wind in a nighttime drainage flow, make carry over of pollutants from one day to another unlikely. This conclusion is reinforced by the observation that the peak ozone days occurred singly in the summer monitoring program of 1976.

However, it appears that wind reversals during midday hours can bring the pollutant cloud back to the region after it has left the model boundary. For ozone the situation cannot be treated correctly by the model since the concentrations changed by unknown amounts while material is outside the analysis region. Given the rapid thickening of the mixing layer, dilution is likely to be far advanced when reentry of the ozone cloud becomes an issue.

While the possibility exists that days could occur when the characterizations involved are not valid the situation described is, however, consistent with maximum ozone concentrations observed in Denver.

Since the boundaries of the Denver Air Quality Model is defined by a 30 x 30 mile square, centered over Denver, the potential downwind affects are not modeled. As discussed in the the section on Mitigation of Air Quality Impacts, downwind ozone and NO_2 concentrations may also be a problem under certain conditions.

The annual average particulate results are estimated with the use of a "calibrated" model which factor the model results to more closely resemble the observations. Also, a large fraction of the model results are attributed to "background" particulate concentrations rather than identified emissions. Therefore, particulate results are sensitive not only to the estimated particulate emissions but, also, to the assumed "background" level and calibration constants.

In predicting future NO_2 concentrations in the Denver region, uncertainty exists as to the present level of NO_2 concentration since there is only one NO_2 monitor and it may not be located so as to pick up the peak concentrations. This is important in that the probability of future violations of the NO_2 standard is based in part on present measured concentrations of NO_2. If, in areas of the Denver Region, the NO_2 standard is being violated where no monitoring presently exists, the likelihood of future violations of the NO_2 standard would be increased.

Effects of Agricultural Crops

The effects of air pollutants have been well documented. However, much is yet to be learned, and methods for forecasting dollar loss as a function of air quality and crop type are not well developed. Reference 908 is the only method which has been applied to obtain national estimates. This method, termed the Factor Method, provides a means for determining loss from a series of factors which account for emissions, meteorology, frequency of episode days, and crop sensitivity. Alfalfa is the only crop for which an alternative method is available. See Reference 909. This method relates dose, in pphm - hours exposure to ozone, to percent reduction in productivity. Using 1974 ozone data from the Welby air quality monitoring station, dollar losses for alfalfa ranged from 16-24 percent. Using the Factor Method, a loss of 20 percent for alfalfa is forecast. When the Factor Method is applied to the crops produced in Adams, Arapahoe, and Boulder counties, generally downwind of Denver, a total loss of over 16 percent is forecast. This amounts to about $6,800,000.

Air quality is expected to improve insofar as ozone is concerned. If the same crop mix and dollar value is assumed for the next 25 years, and a 5 pphm threshold for crop damage is assumed, the dollar losses for 1985 and 2000 are forecast to be about $3,600,000 and $2,200,000, respectively. This amounts to about $95,000,000 over the 25 year period. If the future ozone levels were reduced by 20 percent, the loss over the 25 year period would be reduced 21 percent to $75,000,000.

WATER QUALITY

Three major alternative wastewater collection and treatment programs for the study area were dientified and discussed in Section III of this document: the LOCAL, REGIONAL and NO-ACTION alternatives. Eight 201 facilities plans and their respective planning areas, as shown on Map J. encompass the individual units of these three major alternatives and collectively serve the majority of the study area's stream basin, as discussed in Section II. The status of existing and proposed wastewater facilities is given in Table IV-P. The proposed 201 facility plans addressed in this EIS are underlined.

The following subsections will assess the likely water quality impacts and improvement in beneficial stream uses both for the implementation of these three major point-source control alternatives and for feasible nonpoint-source controls.

Background

From a review of information presented in Section III of this document, it can be noted that the local alternative is typified by the expansion and upgrading of existing facilities, with satellite plants in the Cherry Creek, Clear Creek and lower South Platte basins, whereas under the regional alternative the satellite plants would not be constructed, and excess wastewater flows above the capacity of the upgraded existing facilities would be sent to the Denver NOrthside/MDSDD #1 complex. The no-action alternative is typically the same as the local one except for various time delays in the expansion and upgrading program. Under all the alternatives, the levels of treatment to be provided include additional removal of BOD_5 and suspended solids to effluent levels of 20 mg/l each, and reduction in effluent ammonia levels to approximately 3 mg/l. In addition, residual chlorine levels in the effluents will be reduced. The location and sizing/staging of the various wastewater collection and treatment facilities for the local and regional alternatives are shown on Figures III-A and III-B, respectively, and are discussed in greater detail in Section III.

The Federal Water Pollution Control Act Amendments of 1972 indicate that it is the national goal to meet by 1983 levels of water quality which provides for "protection and propagation of fish, shellfish and wildlife and provide for recreation in and on the water." The Act also declares as a national goal "that the discharge of pollutants into the navigable waters be eliminated by 1985."

During the course of the 208 planning program in the Denver area, levels of water quality necessary to meet the 1983 goals have been suggested by the Colorado Water Quality Control Commission; and the Denver Regional Council of Governments (DRCOG), along with their con-

Table IV-P. STATUS OF EXISTING/PROPOSED WASTEWATER COLLECTION AND TREATMENT FACILITIES UNDER THE LOCAL, REGIONAL AND NO-ACTION ALTERNATIVES

Basin	Existing or proposed facility	Status under local alternative	Status under regional alternative	Status under no-action alternative
Bear Creek	Morrison	Assumed will maintain present level of secondary treatment but will add nutrient removal to reduce effluent ammonia (NH_3-N) to 3 mg/l	Same as local	Same as local but but ammonia removal facilities would be added at later date
Cherry Creek	Glendale	Assumed will maintain present level of secondary treatment but will add nutrient removal to reduce effluent NH_3-N to 3 mg/l and reduce residual Cl.	Same as local	Same as local
		AWT plant to be built in 1985 only if feasible at that time. Effluent at secondary level when used for reuse (industrial/agri), tertiary when discharged to Cherry Creek. Flows above plant capacity sent to Denver/Northside/Metro #1 system	All flows sent to Denver/ Northside/Metro #1 system (except Glendale) via Cherry Creek/Goldsmith Gulch interceptor	Same as regional but construction of interceptors delayed two years
Sand Creek	Aurora (New plant 30-40 mgd at Aurora site, renamed Sand Creek Satellite)	Expanded/upgraded new facility to meet effluent levels of 20 mg/l each for BOD_5 and suspended solids (SS) and NH_3-N to 3 mg/l. Residual chlorine (Cl) reduced to 0.005 mg/l and fecal coliform (Fc) to 1000 MPN/ 100 ml. Effluent to Quincy Reservoir for reuse. Flows above plant capacity to Metro #1 via interceptor for treatment	All flows via interceptor to Metro #1 for treatment. Aurora plant abandoned.	Same as regional but construction of interceptors delayed three years
	Fitzsimmons	Plant abandon and flows sent to Sand Creek Satellite (Aurora new plant)	Plant abandoned and flows via interceptor to Metro #1 for treatment	Same as regional but construction of interceptor delayed three years.

Table IV-P. (Continued). STATUS OF EXISTING/PROPOSED WASTEWATER COLLECTION AND TREATMENT FACILITIES UNDER THE LOCAL, REGIONAL AND NO-ACTION ALTERNATIVES

Basin	Existing or proposed facility	Status under local alternative	Status under regional alternative	Status under no-action alternative
Clear Creek	Coors	Assumed to be upgraded to meet secondary treatment levels with nutrient removal to reduce effluent NH_3-N to 3 mg/l	Same as local	Same as local
	Clear Creek Satellite (also serving North Table Mtn, Applewood, and Pleasant View) (6.56 mgd)	Assumed to construct AWT plant meeting effluent levels of 20 mg/l each for BOD_5 and SS, 3 mg/l for NH_3-N, residual Cl to 0.05 mg/l, and FC of 1000 MPN/100 ml. Effluent levels may be more stringent depending upon discharge/reuse.	Flows via interceptor to Metro #1 for treatment	Local alternative delayed three years
	Wheatridge, Clear Creek Valley, Arvada, Crestview	Plants abandoned and flows via interceptor to Metro #1 for treatment	Same as local	Local/regional but construction of interceptor delayed three years
South Platte				
South Metro	Englewood/Littleton (20 mgd)	The Englewood and Littleton plants are not expanded in capacity but NH_3-N and Cl removal facilities are added. New AWT plant being constructed near Englewood to handle flows in excess of these two facilities. AWT effluent levels assumed at 20 mg/l each for BOD_5 and SS, NH_3-N of 3 mg/l and residual Cl at 0.05 mg/l	Existing plants upgraded to AWT levels (as shown in local alternative) with flows in excess of plants capacities sent to Denver/Northside/Metro #1 system	Addition of NH_3-N and Cl removal facilities at existing plants delayed one year. Effluents used for non-crop irrigation rather than discharge to South Platte (some portion of effluent)
Middle	South Lakewood	Expand/upgrade to ∿5 mgd AWT plant and either discharge to South Platte or reuse for urban irrigation	Abandon existing plant and transport all flows to Metro #1 interceptor/plant	Maintain existing plant with effluent sent to Metro #1 for further treatment.
Lower	Metro #1	No additional added capacity above 185 mgd. NH_3-N removal to various levels depending upon effluent discharge/reuse options	Capacity expanded to 260-270 mgd with NH_3-N removal to various levels depending upon effluent discharge/reuse options	Local alternative with further expansion beyond 1985 delayed

Table IV-P. (Continued). STATUS OF EXISTING/PROPOSED WASTEWATER COLLECTION AND TREATMENT FACILITIES UNDER THE LOCAL, REGIONAL AND NO-ACTION ALTERNATIVES

Basin	Existing or proposed facility	Status under local alternative	Status under regional alternative	Status under no-action alternative
	South Adams County	Expand/upgrade existing plant to 5-6 mgd with NH_3-N removal. Effluent at 20 mg/l each BOD_5 and SS, NH_3-N at 3.5 mg/l, and FC at 200 MPN/100 ml. Residual Cl at 0.5 mg/l. Effluent discharge to South Platte.	Plant expanded to 3.75 mgd by 1977 but abandoned by 1985 with all flows to Metro #1.	Expansion to 5-6 mgd delayed one year. No NH_3-N removal provided
	Lower South Platte Satellite Plant at 164th Avenue (8.7 mgd)	New plant to treat flows from Brighton; Lower Thornton; and 1st, 2nd, and 3rd Creeks. Effluent at 20 mg/l each BOD_5 and SS, NH_3-N at 3 mg/l, FC at 1000/100 ml, and residual Cl of 0.05 mg/l. Flows from Upper Thorton and NWSWDS to Metro #1. Option to pump some of plant flow to Big Dry Creek plant	All flows to Metro #1	Local alternative with construction of new plant delayed four years
Big Dry Creek	Broomfield/Westminster	Big Dry/Westminster plant expanded upgraded to 8 mgd with 20 mg/l each BOD_5 and SS, NH_3-N at 2.5 mg/l, FC at 200/100 ml, and residual Cl at 0.5 mg/l. Plant treats excess flows from Broomfield and flows from Westminster and some of Thornton. Discharge to either Farmers Highline Canal or Big Dry Creek.	Maintain current capacity of Big Dry/Westminster plant at 2 mgd, provide NH_3-N removal. Maintain other plants at existing capacity and excess flows to Metro #1	Expand Big Dry/Westminster to 5 mgd with NH_3-N removal. Maintain other plants and excess flows to Metro #1.
Coal Creek	Erie, Lafayette, Louisville 1985: 0.4 mgd, 1.3 mgd, 1.3 mgd; 2000: 1 mgd, 2 mgd, 2 mgd	Expand/upgrade existing facilities to 20 mg/l each BOD_5 and SS, NH_3-N at 3 mg/l, FC at 200/100 ml	Same as local	Same as local but expansion/upgrading delayed
Boulder Creek	Boulder/White Rocks 18 mgd	Add tertiary treatment via percolation ponds with percolate to Boulder Creek.	Same as local	Same as local

sultants, has made an extensive review of the various water quality criteria necessary to satisfy various beneficial uses of the area's surface waters while meeting the 1983 goals. Recent acitivities by DRCOG in developing wastewater treatment strategies for the 208 planning areas have resulted in the assignment of four alternative classification levels of water quality according to groupings of eight proposed water uses for the Denver area (Reference 261). Alternative Classification 1 levels are governed primarily by primary-contact, cold-water-biota and potable-supply water uses, and the alternatives descend in levels of water quality to Alternative Classification 4 levels, which are primarily secondary-contact agriculture and wildlife uses and which generally represent present water quality.

Recent activity with the 208 planning program has centered on obtaining both citizen and internal task force review of the assignment of stream classifications for specific areas within the 208 planning area. These specific areas and the alternative classification levels selected by the 208 Task Force following their review of the Draft Wasteload Allocation Report (Reference 262), are shown in Table IV-Q. Significant to the review of this table is the knowledge that the recommended 208 planning levels were based in part upon the costs associated with providing the wastewater treatment needed to meet each of the four levels and that these costs in turn were predicated upon meeting the levels during 7-day, 10-year low flows, not historical average flows. It is likely that treatment efficiencies required, and hence the concomitant costs, would have been lower had some average been selected for wasteload allocation analyses rather than using low flows, and this would have had an effect on the resultant recommended alternative classification levels.

Shown in Table IV-R are the water quality criteria suggested as necessary and sufficient to meet the 1983 goals within the study area.

The information presented in Table II-H of Section II indicates that the only location within the study area that presently consistently meets the water quality criteria established to meet the 1983 goals presented in Table IV-R for all seasons is the upstream reach of the South Platte, above Chatfield Reservoir. The upper portions of the remaining basins are, for the most part, well within the 1983 goals except for the nutrients ammonia and phosphate, during all seasons; and fecal coliforms, during the spring at Bear Creek/Morrison and Clear Creek/Golden. Thus, the background quality of water entering the major basins within the study area is, with the exception of nutrients, high. However, as can be seen from the review of Table II-H, the water quality of the streams is degraded as they pass through the lower portions of their respective basins, particularly with regard to nutrients and fecal

Table IV-Q. SELECTED ALTERNATIVE CLASSIFICATION LEVELS BY SPECIFIC STREAM AND/OR STREAM AREA

	Alternative Classification Level
South Platte	
Dartmouth Avenue to MDSDD #1 outfall	4[a]
MDSDD #1 outfall to Weld County line	2
Cherry Creek below reservoir	2
Sand Creek	4[b]
Clear Creek below Golden	2[c]
Big Dry Creek below Standley Reservoir	3
Coal Creek - Highway 93 to mouth	2
Boulder Creek - 75th Street outfall to mouth	2

[a] To consider potential water supply conflict with Brighton and Thornton.

[b] To consider water supply for South Adams.

[c] Alternative 1 to be kept open as an option

Source: Reference 2.

NOTE: Alt. 1, primary contact, cold-water viota, water supply; Alt. 2, warm-water biota, water supply; Alt. 3, warm-water biota, secondary contact; Alt. 4, Secondary contact, agriculture.

coliforms. The 1983 water quality goals for these pollutants are routinely exceeded throughout the year. For all locations, temperature criteria are met, on the average by season, except during the winter, when the criterion for swimming is exceeded. However, this activity is unlikely to occur during the winter season. Dissolved oxygen levels are still relatively high throughout the major basins during all seasons, with the exception of South Platte above Littleton during the summer. This may in part be due to the release of

Table IV-R. WATER QUALITY CRITERIA TO MEET 1983 GOALS

Parameter	
Temperature	
Minimum	15°C (for swimming)
Maximum	20°C (for cold-water fishery) 30°C (for warm-water fishery) 35°C (for swimming)
Dissolved oxygen	5 mg/l (for warm-water fishery) 7 mg/l (for cold-water fishery)
Total dissolved solds	2,000 mg/l
Ammonia (NH_3-N)	0.02 mg/l (un-ionized)
Phosphate (total)	0.1 mg/l
Fecal coliform	200 MPN/100 ml

Source: Reference 261.

low-level dissolved oxygen waters from Chatfield Reservoir during the summer months, the reason for which is unknown at this time. Levels of total dissolved solids, although below the suggested levels for the 1983 goals in all major basins, do tend to increase substantially from upstream in any basin, and within the Sand Creek basin are above the level suggested for its use classification, one of the uses being that of a water supply source for urban irrigation.

It is within this general context that the three major wastewater collection and treatment alterantives in this report were developed and will be analyzed in the following subsection, as to their likely impacts upon water quality and the likelihood of their meeting or approaching the 1983 water quality goals within the context of the 208 draft plan for control of nonpoint sources of pollutants. The status of existing or proposed wastewater collection and treatment facilities within the study area's stream basins is indicated in Table IV-P. In addition, it should be noted that there is the likelihood that wastewaters from the City of Golden will be treated at an advanced treatment facilitity, which would allow the City of Golden the option of reusing the effluent in the upper portion of Clear Creek.

The Local Alternatives

The upgrading of the Morrison Sewage Treatment Plant (STP) to provide ammonia removal is expected to provide some reduction in this point source loading to Bear Creek. However, as can be observed in Table II-I, point sources do not account for a significant portion of the ammonia loading in the basin, particularly in the upper portion. It appears necessary to provide a fairly high degree of nonpoint source control in order to reduce loadings of all constituents which are adversely affecting the Bear Creek basin, as can be noted in Table II-H.

On Cherry Creek above the reservoir, the option for an advanced waste treatment (AWT) plant exists. This plant would have a very high level of treatment when discharging to Cherry Creek and thence to the reservoir. However, this would occur only during non-irrigation seasons. At other times, effluent would only be treated to the levels necessary for agricultural irrigation/reuse. In theory, if the additional flows during winter into the reservoir were equalled by additional downstream discharges from the reservoir, the flow in Cherry Creek would about double in 1985 and increase another 50 percent in 1995. This coupled with Ammonia removal at the Glendale plant would improve water quality levels throughout lower Cherry Creek. Phosphate would remain a problem. Therefore, any augmentation of creek flow would be limited to winter months. Beneficial uses of secondary contact recreation would be limited to that portion of Cherry Creek between the reservoir and Glendale as the remainder of the creek is channelized with vertical concrete walls, and access is limited.

The provision of AWT facilities at the present Aurora STP site is expected to result in a significant reduction in point-source loadings of ammonia in Sand Creek. However, by removing the effluent flows from the stream and transferring water to Quincy Reservoir, it appears that stream flows in Sand Creek would then be too low to provide secondary-contact recreation opportunities. The question of water rights and transfer appears to be of major importance in this basin. Nonpoint source controls would then become very important in this basin because it is likely that stream flows necessary for secondary-contact recreation would occur only during the spring season, when storm runoff augments the base flows.

The provision of AWT facilities on Clear Creek (Golden and Satellite plants), along with improved treatment at Coors and the removal of effluent flows at the STP's in the lower portion, would vastly improve the water quality of Clear Creek. As was indicated in Section II (Existing Water Quality), this basin is significantly impacted by point-source loadings, particularly by BOD_5, ammonia and phosphate. It appears, however, that in order to meet, or at least approach 1983 water quality goalds, provision for phosphate removal at point sources will be necessary under the local alternative, particularly if the AWT facilities discharge to Clear Creek. Were the Golden and Clear Creek Satellite plants to reuse the effluents for irrigation, phosphate removal might not be necessary unless irrigation return flows were high in phosphates. Under the latter option, the major point source on Clear Creek would then be the Coors STP, which because of its major contribution in flow volume during the summer would likely have to provide phosphate removal in order for Clear Creek to approach 1983 goals.

Another major problem area, the portion of the South Platte between Littleton and 38th Avenue, would be alleviated by the upgrading of treatment at the Littleton and Englewood STP's in addition to the combined AWT plant at Englewood. As was noted in Table II-H, point-source loadings in this portion of the South Platte are significant with regard to BOD_5, ammonia and phosphate. Once again, however, phosphate removal in addition to planned reductions in BOD_5 and ammonia appear necessary in order to approach 1983 goals.

Within the middle portion of the South Platte, the expansion and upgrading of the South Lakewood STP will have a positive, although less significant, impact upon improving water quality in the South Platte. The removal of ammonia from the plant's effluent would benefit the South Platte waters, but it is unlikely that phosphate removal for South Lakewood would be warranted because of the dominance of nonpoint sources of phosphate in this area. This portion of the South Platte is clearly dominated by nonpoint sources for all water quality parameters (see Table II-H), and any additional expenditures at the South Lakewood STP about secondary treatment with ammonia removal would not be likely to prove cost-effective. Highly effective non-point source controls would be needed to achieve 1983 goals.

Within the lower South Platte, existing water quality is most clearly dominated by point sources, and most particularly by MDSDD #1. The upgrading of effluent quality at Metro and South Adams County STP's would improve water quality above Henderson, and the satellite plant serving the Brighton/Thornton area would also have a positive impact below Henderson. However, because of the very substantial contribution of loadings from Metro, particularly in total dissolved solids, BOD_5 and Ammonia, it appears that diversion of a sizeable portion of Metro's effluent to Burlington Ditch for irrigation reuse would not only have a greater positive effect upon water quality in the South Platte but might also be cost-effective in terms of degree of ammonia removal and the possible elimination of necessary phosphorus-removal facilities.

Under the local alternative, the remaining facilities in the Big Dry, Coal and Boulder Creek basins are to continue discharging to their respective streams with high levels of effluent quality for protection of stream quality. The option to discharge effluent from Big Dry STP to the Farmers Highline Canal for reuse as irrigation water appears to be a better use of the basin's water (Reference 261). Provided the necessary transfer of water rights can be arranged, this option also appears to best protect the water quality of Big Dry Creek; however, significant stream flow reduction is likely.

From an evaluation of information presented in Table IV-P and from the Wasteload Allocation Report (Reference 261), it appears that the levels of point-source treatment proposed in the local alternative may provide stream water quality at Classification Level 3 (warm-water biota and secondary-contact uses). As can be noted from Table IV-Q, this alternative, then, provides in-stream water quality which is lower than that suggested for most of the study area basins, i.e., Classification Level 2. Also, it is unlikely that the 1983 goals specified in Table IV-Q would be met by these point-source controls, particularly in view of existing background levels of ammonia and phosphate caused primarily by nonpoint pollution sources. However, Classification Level 2 (warm-water-biota and water-supply uses), that is desired in the more critical areas of the Cherry Creek, Clear Creek and lower South Platte basins, may possibly be met during periods of average daily streamflows, particularly if sizeable portions of Metro's effluent were diverted to Burlington Ditch and the Clear Creek and Cherry Creek satellite plants were constructed to produce effluent at quality levels sufficient either for desired stream water quality or for indirect reuse.

The Regional Alternative

In the Bear, Cherry, Sand and Clear Creek basins, only the Morrison, Glendale and Coors STP's would be upgraded, while all other wastewater would be transported for eventual treatment at the Metro plant. However, the resultant reductions in base streamflow in Cherry and Sand Creeks would likely reduce the potential for secondary-contact recreation to the spring season alone, when nonpoint source control would become necessary. In the Clear Creek basin, the reduction in streamflow might impair water rights of irrigation diversion flows. The overall impact would be the basin-wide reduction in Clear Creek base flows, resulting in a greater need for nonpoint-source controls within the basin that might otherwise be necessary to compensate for the loss of dilution available with higher base flows.

With the portion of the South Platte immediately below Littleton the existing Littleton and Englewood STP would be upgraded, with all flows in excess of the plant's capacities sent to Metro. There would be reductions in point-source loadings, particularly with regard to ammonia and BOD_5, and the transport of excess flows to Metro would further reduce the impacts of point sources on the water quality of South Platte in this area.

By transporting all domestic wastewaters from the middle portion of the South Platte to Metro for treatment, the impact of these point sources would be removed. However, as can be noted from Table II-I, the major contribution of pollution in this portion of the South Platte stems from nonpoint sources. Recognizing that nonpoint source pollution would probably occur more frequently during the spring, the improvement in water quality for the South Platte in this area would likely be more noticeable during the summer season. Loss of the discharge from South Lakewood would be insignificant as it would contribute only 10 percent of low flow in the South Platte. This, coupled with the provision of South Platte stream bank parks, would increase the opportunity for secondary-contact recreation during the summer, particularly if upstream water quality improved in the portion of the South Platte immediately below Littleton.

With Metro facility expanded to handle all the flows diverted from the other basins, the lower South Platte basin would experience the flow of a very large point source at its upper portion, with other point sources downstream from Metro eliminated. This configuration, as compared to three smaller point sources located along the South Platte from Commerce City to Brighton under the local alternative, might result in considerably reduced stream water quality in a stretch of the South Platte below Metro (in comparison with the more uniform level of water quality obtainable under the local alternative), although there would be some downstream recovery. The extent and degree of this reach having reduced water quality is unknown at this time. It is likely, however, that under the regional alternative equal or greater consideration would have to be given to discharging a significant portion of Metro's effluent to Burlington Ditch, not only to protect water quality and downstream water supply uses of the South Platte but also to reduce the sizeable expenditure of funds likely to be necessary for the reduction of ammonia, and possible phosphate, to levels acceptable for stream discharge.

The configurations and probable water quality impacts for Coal Creek and Boulder Creek would be the same as for the local alternative, i.e., the improvement of water quality in streams, the base flows from which come principally from STP effluents. However, the option of reusing effluent from the Big Dry Creek STP for irrigation purposes in the Farmers Highline Canal is not included in the regional alternative, and basin flows are transferred to Metro rather than being utilized to maintain streamflows in Big Dry Creek.

Unlike the local alternative, there have been no definitive studies with regard to the overall impact of the regional alternative on the study area's water quality. The individual stream basin impacts of the various facility plans have been discussed above, and the overall impact may be assessed in general. Although most point sources are removed from the Sand, Clear and Middle South Platte basins, thus reducing their adverse impacts upon these streams (Table II-I), by doing so the basins are rendered more susceptible to fluctuations in base flow and to influences of non-point sources which, as noted in Section II, are significant within the study area. It is therefore likely that the control of non-point sources in these basins will become more important in the effort to approach 1983 water quality goals. The impact of point sources in the lower South Platte becomes more important for the Metro facility than in the local alternative, as discussed above. It is likely that in order to approach 1983 water quality goals for the lower South Platte, the Metro facility either would have to provide a very high level of treatment or would have to divert a very significant portion of its effluent to the Burlington Ditch.

The No-Action Alternative

As can be noted from Table IV-P, the overall status of the no-action alternative is to maintain the existing plant configurations for the next several years, after which time flows in the Sand and Cherry Creek basins and in the lower portion of Clear Creek basin would be sent to Metro, and satellite plants would be constructed in the Clear Creek and lower South Platte basins, with expansions of the Big Dry Creek plant to handle more of its basin's wastewaters. The South Lakewood plant would sent its effluent to Metro for further treatment; the Englewood/Littleton facilities would utilize some portion of their effluent for non-crop irrigation; and the South Adams STP would be expanded to handle more of its basin's wastewaters.

The immediate impact of this alternative is the continuing degradation of water quality in the study area; i.e., the water quality will remain essentially at Classification Level 4 (secondary-contact and agriculture water uses). Following the period of upgrading, expansion and routing of wastewater flows, as described earlier, the impact of point sources in the basins within the study area would be reduced, particularly in the Sand, Cherry and middle South Platte basins.

Although no rigorous assessment of the stream water quality that will result from the implementation of this alternative is available, it appears that the alternative does combine some of the best features of the two previous alternatives. There is not such a heavy reliance upon treating most wastewater flows at the Metro facility; the Big Dry Creek basin maintains its option of irrigation reuse of its effluent; point sources are treated in the South Metro portion of the South Platte, with some portion of the effluent reused for irrigation; and the impact of point sources in the lower South Platte is reduced and spread out rather than being concentrated in one portion. However, point sources will still contribute to water quality problems in the upper portion of the Clear Creek basin unless treatment levels at the satellite plant are such that either some form of effluent reuse can be implemented or downstream water quality is protected. Under this alternative, non-point sources become the influencing factor in the Sand, Cherry and middle South Platte basins. It is likely that resultant stream water quality within the study area under implementation of the no-action alternative will approach that of the local alternative, for the possible attainment of Classification Level 3 (warm-water biota and secondary contact recreation uses).

The principal differences from the no-action alternative to the local alternative is a likely delay of 3 years in the implementation of point source water quality improvements and a shift in the burden of paying for these improvements from the Federal Government (national taxpayer) to the local government and local taxpayers.

Summary

Utilizing information from Section III of this report and from Reference 261, Table IV-S indicates the anticipated 1985 nonpoint source loadings by basin and the resultant point-source loadings within the same basins after implementation of each of the three major alternatives. It should be noted that the point source loadings assume discharge to the respective creeks, with the exception of the Sand Creek Satellite plant, as mentioned previously, which will discharge its entire effluent to Quincy Reservoir under the local alternative, and Boulder Creek, which discharges to percolation ponds. The levels of treatment for the wastewater facilities were noted in Table IV-P except for Metro, which is assumed to discharge a secondary level effluent (i.e. BOD_5 of 30 mg/l and Ammonia of 3 mg/l). Phosphate levels in all treatment plant effluents are assumed at 8 mg/l. The Boulder Creek plant, which will discharge its effluent to percolation ponds, is assumed to have a negligible effect upon Boulder Creek.

It can be seen by comparing Tables IV-S and II-H that nonpoint sources of pollution are expected to increase throughout the study area by approximately 49 percent for each of the four parameters shown in Table IV-S. This increase is a direct consequence of further urbanization in the Denver Region. Those basins with the largest increase are Bear Creek (200-220 percent), Cherry Creek (BOD_5 and Phosphate 75 percent, Ammonia 100 percent), Clear Creek (60 percent), and Lower South Platte (70 percent). Pollutants from point sources would also be expected to increase as a result of growth, but treatment by wastewater treatment plants may negate or offset growth effects, and/or pollutant loadings from point sources may be minor compared to nonpoint loadings. For example, by 1985, on Clear Creek under the local alternative, the nonpoint loading for BOD_5 will increase by 60 percent, whereas the point source loading will decrease 30 percent compared to 1972. Thus, while point sources dominated total loadings in the Clear Creek basin in 1972, non-point loadings will dominate in 1985. This would be true even if nonpoint loadings were reduced by one-third under an effective nonpoint source control program.

An examination of the total basin-wide loadings in Table IV-S indicates that the majority of BOD_5, Ammonia, and phosphate will originate from point sources. However, if those loadings in the lower South Platte, principally from the Denver Northside/Metro complex are deleted, the only pollutant still dominated by point sources is phosphate. All other pollutants are dominated by nonpoint sources. It must be remembered that nonpoint sources of pollutants in most cases only affect water quality when they enter a stream via some runoff event such as snowmelt or precipitation. Thus, their contribution is not constant as are the contributions from point sources Nevertheless, the Bear, Cherry, and Sand Creek basins as well as the portion of the South Platte flowing through Denver proper are dominated by nonpoint sources of pollutants now and in 1985, and would remain so even if a 35 percent reduction of nonpoint loadings were achieved in 1985. The upstream portion of the South Platte would be dominated by point sources, namely

Table IV-S. ANTICIPATED POINT AND NONPOINT SOURCE LOADINGS IN THE YEAR 1985 BY STREAM BASINS
(pounds per day)

	NH_3-N				PO_4			
	Nonpoint source	Point Source			Nonpoint source	Point Source		
Basin		Local	Regional	No-action		Local	Regional	No-action
Bear Creek	235	2	2	2	210	5	5	5
Cherry Creek	360	225 (90)	25	25	320	600 (87)	70	70
Sand Creek	560	0	0	0	530	0	0	0
Clear Creek	540	390	225	390	490	1,560	1,130	1,560
South Platte								
South Metro	280	575	490	575	280	1,470	1,240	1,470
Middle	800	55	0	0	750	150	0	0
Lower	540	3,850	4,770	4,290	550	10,300	12,700	10,400
Subtotal	3,315	5,097 (4,962)	5,512	5,282	3,110	14,085 (13,572)	15,145	13,505
Big Dry Creek	230	100	90	125	200	330	240	330
Coal Creek	170	75	75	75	150	200	200	200
Boulder Creek	440	-	-	-	410	-	-	-
Total	4,155	5,272 (5,137)	5,677	5,482	3,870	14,615 (14,102)	15,585	14,035

Note: Values in parenthesis for Cherry Creek - Local Alternatives are those resulting from high levels of tertiary treatment at the Cherry Creek Satellite plant.

Littleton/Englewood, for BOD_5, Ammonia, Phosphate, and TDS. The Clear Creek basin will become dominated by non-point sources for BOD_5 and Ammonia, but remain dominated by point sources for phosphate and for TDS. A 35 percent reduction in non-point sources as contemplated in the 208 plan, would not change this conclusion except that the contributions of Ammonia would be about equally balanced between point and nonpoint sources.

One particular point should be noted: in the local alternative, the Cherry Creek Satellite plant would appear to contribute significant loads of BOD_5, NH_3-N and PO_4 to its basin were the effluent to be discharged year round. The discharge levels for the plant assumed under this alternative for these parameters were 20,3 and 8 mg/1, respectively. Were these levels reduced to 5 mg/1 BOD_5, 1 mg/1, NH_3-N and 0.3 mg/1 PO_4 (tertiary treatment level 14, as noted in Reference 262), the Cherry Creek basin point source loadings would be reduced to 430 pounds per day BOD_5, 90 pounds per day NH_3-N and 87 pounds per day PO_4. It is therefore likely that the incorporation of tertiary treatment at the Cherry Creek satellite plant, with the effluent discharged only during the winter/non-irrigation season, would significantly enhance the Cherry Creek basin.

There are two basic approaches to reducing the impact of Metro's discharge on the lower South Platte. First is reducing the amount of the discharge, and second is improving effluent quality with higher levels of wastewater treatment. The first approach is a limited possibility in that increased amounts of effluent may be diverted to agricultural irrigation via the Burlington Ditch during the irrigation season. If the amount of effluent discharge to the South Platte were reduced to 15 million gallons per day (mgd) under the local and no-action alternatives or 25 mgd under the regional alternative, point sources for BOD_5 and Ammonia would then be comparable to nonpoint sources. However, point sources of phosphate would still be two to three times nonpoint loadings.

Upgrading of effluent quality through tertiary treatment to levels of 5 mg/1 BOD_5, 1 mg/1 Ammonia, and 0.3 mg/1 phosphate for the Lower South Platte basin, Metro plant, would have the following results. Under the local and no-action alternatives, BOD_5 loadings from point sources would be comparable with non-point loadings. Point sources for Ammonia and Phosphate would be two and three times non-point loadings. Under the regional alternative, point sources would still greatly dominate.

As mentioned previously, the implementation of any of the three major wastewater collection and treatment alternatives is likely to result in in-stream water quality approaching Classification Level 3, that being the use of stream waters for secondary-contact recreation and protection of warm-water biota. Present study area water quality levels are at Classification Level 4, secondary-contact and recreation uses. Previous investigations under 208 planning wastewater alternatives nearly identical to the local alternative presented herein have indicated the anticipated percent of the time that Classification Levels 3 and 4 cannot be met by point-source controls alone. Table IV-T and IV-U indicate, respectively, these time percentages during the year when the present (Level 4) and expected future (Level 3) water quality will not be met for the local and no-action alternatives. The implementation of the regional alternative is expected to lower the percentages in the Cherry, Sand and Clear Creek basins and to increase them in the lower South Platte (MDSDD #1 toWeld County line).

A review of these two tables indicates that as desired water quality in the study area increases, nonpoint source controls become more necessary. Also, nonpoint source problems appear to be more pronounced in the Sand, Cherry and middle South Platte basins and, to a lesser extent, in the lower portions of the Bear and Clear Creek basins.

In the metropolitan area, the effect of non-point sources on meeting stream standards is considerable. The 208 plan has identified two major parameters, phosphate and fecal coliform, from non-point source runoff that could constrain the attainment of the "swimmable" criterion for Front Range streams without some form of non-point source control. Assuming advanced treatment of the point sources, there are fewer water quality limitations to attaining the "fishing" and non-contact recreation criteria, as shown in Table IV-V.

It has been noted in the 208 planning studies and Tables IV-T and IV-U demonstrate, that even the most stringent control of effluent quality from point sources will not be sufficient for meeting 1983 water quality goals, and that some nonpoint source control will be necessary.

Table IV-T. PERCENT OF TIME DESIRED WATER QUALITY CANNOT BE ACHIEVED BY POINT SOURCE CONTROLS ALONE. CLASSIFICATION LEVEL 4

Stream and location	Primary contact	Secondary contact	Agriculture	Cold water biota	Warm water biota	Public water supply (Groundwater)	Public water supply (Surface water)	Wildlife watering
South Platte: Headwaters to Chatfield Dam	0	0	0	5	X	0	0	0
South Platte: Chatfield Dam to Dartmouth Ave.	0	0	0	5	X	0	0	0
South Platte: Dartmouth Ave. to MDSDD#1	X	40-50	40-50	X	0-10	X	X	40-50
South Platte: MDSDD#1 to Weld County Line	X	40	40	X	X	X	X	40
Bear Creek: Headwaters to Bear Creek Dam	100	5	5	0	X	15	5	5
Bear Creek: Bear Creek Dam to Mouth	100	50	50	X	5	100	50	50
Cherry Creek: Headwaters to Reservoir	X	0	0	X	X	0	0	0
Cherry Creek: Reservoir	40	0	0	X	0	0	0	0
Cherry Creek: Reservoir to Mouth	X	50	50	X	X	X	X	50
Clear Creek: Headwaters to Golden	100	0	0	X	X	70	0	0
Clear Creek: Golden to Mouth	X	10-40	10-40	X	0-5	X	X	10-40
Sand Creek: Headwaters to Mouth	X	60	60	X	X	X	X	60

NOTE: X - Not a designated use

SOURCE: Ref. 1

Table IV-U. PERCENT OF TIME DESIRED WATER QUALITY CANNOT BE ACHIEVED BY POINT SOURCE CONTROLS ALONE. CLASSIFICATION LEVEL 3

Stream and location	Primary contact	Secondary contact	Agriculture	Cold water biota	Warm water biota	Public water supply (Groundwater)	Public water supply (Surface water)	Wildlife watering
South Platte: Headwaters to Chatfield Dam	0	0	0	5	X	0	0	0
South Platte: Chatfield Dam to Dartmouth Ave.	0	0	0	5	X	0	0	0
South Platte: Dartmouth Ave. to MDSDD#1	X	40-50	40-50	X	0-10	X	X	X
South Platte: MDSDD#1 to Weld County Line	X	40	40	X	5-15	X	X	X
Bear Creek: Headwaters to Bear Creek Dam	100	5	5	0	X	15	5	5
Bear Creek: Bear Creek Dam to Mouth	100	50	50	X	5	100	50	50
Cherry Creek: Headwaters to Reservoir	X	0	0	X	X	0	0	0
Cherry Creek: Reservoir	40	0	0	X	0	0	0	0
Cherry Creek: Reservoir to Mouth	X	50	50	X	X	100	X	50
Clear Creek: Headwaters to Golden	100	0	0	X	X	70	0	0
Clear Creek: Golden to Mouth	X	10-40	10-40	X	0-5	80	10-40	10-40
Sand Creek: Headwaters to Mouth	X	60	60	X	15	X	X	60

NOTE: X - Not a designated use

SOURCE: Ref. 1

Table IV-V. CONTROL REQUIREMENTS FOR POINT AND NONPOINT SOURCES

Pollutant	Principal Stream Use Affected	Control Requirements
Phosphate	Body Contact	Will likely require a combination of point and non-point source controls
Ammonia	Fishery	Can currently only be effectively removed from point sources.
Nitrate	Water Supply Fishery	Can be most effectively controlled at point sources.
TDS	Agriculture Water Supply	Can be effectively controlled through non-point source programs.
Fecal Coliform Fecal Streptocci	Body Contact	Must be approached from both point and non-point sources together.
Dissolved oxygen levels (BOD, nitrification)	Fishery	Largely a function of point source control on a sustaining basis and of non-point source control for storm-related events. Non-point source control cannot make up for a lack in point source control.
Chlorine	Fishery	Point source control.

GROWTH-INDUCED IMPACTS ON THE REGION'S ENVIRONMENTALLY SENSITIVE AREAS

Wastewater collection and treatment is one of several basic services local government provides to serve the needs of its citizens. Planning to accommodate a future population and its need for wastewater treatment and disposal is a prudent and responsible function exercised by local governments. Construction and operation of these facilities in accordance with plans to accommodate future growth must be considered a contributing factor to the environmental consequences of future growth. The same is true for other services such as highways, schools, and water supply. On a regional basis, it is rare that the provision or lack of a single "municipal" service stimulates or constrains regional growth, and can be considered the dominant factor in growth-related environmental impacts. It can, however, influence development patterns. The purpose of this section is to summarize the impacts of changes expected to occur in the region as a result of the population increases and resultant development patterns projected for the year 2000 for which the facility plans and the Clean Water Plan were developed. A more complete assessment of these impacts may be found in Appendix B.

Climate

Construction activities randomly located through the region will often be a factor in the local severities of Chinook wind episodes by providing particulates that can be blown downwind from the construction site to affect traffic, equipment, structures and crops. The significance of this impact will range from that of a nuisance to that of a hazard. Further development in the wind corridors of the South Platte River and Clear Creek valleys will increase the potential for wind damage in these areas. Early morning traffic problems ranging from slow-downs to chain-reaction accidents will increase due to radiation fog as traffic volumes continue to grow in response to suburban growth.

Geology

Grading of undulating natural landscapes for urban development can drastically modify landforms, change drainage patterns and alter visual appearances. Grading impacts can be especially significant in a local area where massive cuts and fills are made for roadbuilding and hillside terracing, and in floodplains where protective devices such as channelization, diversions and in-stream structures are constructed. On a regional scale, these activities are likely to have cumulative impacts on water quality. However, gross, visual land form characteristics will not be radically altered. Urban development will occur near unique and significant geological structures and formations which will threaten many of them with over-use and vandalism. The region's geological hazards to development are generally local in nature and do not pose any region-wide threats to urban expansion.

Soils

Current reports are that due to the effects of the current drought, many Colorado farmers on the plains are turning under their winter wheat crops which is leaving the dry ground surface exposed to the season's high velocity winds. Wind erosion can significantly reduce or destroy land's agricultural production capabilities. In terms of soil loss, however, water erosion is usually a more significant regional impact of urban expansion than wind erosion. Construction sites left exposed to precipitation and run-off experience sheet erosion, rilling and, at times, gullying. All of these can clog drainage improvements; alter the drainage net by added streambank scouring, turbidity, siltation and sedimentation; increase receiving water temperature; and reduce chemical and biological water quality. These impacts can have cumulative impacts on the region's drainage basins and water quality.

Hydrology

Urban expansion can impact sensitive hydrologic features including wetlands/marshes, floodplains, groundwater and lakes in three main ways. These include: (1) encroachment into or elimination of the feature, (2) change in the amount and distribution of water flowing to or through the feature and (3) change in the quality of water flowing to or through the feature.

Construction of buildings, roads and bridges together with regrading for development can result in encroachment into or elimination of wetlands/marshes, lakes and natural floodplains. The proximity of development can affect both the flora and fauna of the hydrologic element. Development can alter the extent of the flood hazard area limits through alteration of the conveyance capacity of the natural water course. Unwise occupation of the floodplain can seriously increase the potential for flood damage.

Development can cause an increase in the base flow of water reaching wetlands/marshes, lakes and floodplains, and the flora and fauna may be affected. Lawn irrigation return flow, interception of the groundwater by storm and sanitary sewer systems, and leaky water distribuiton systems may be responsible for the increased flow. Development may cause a decline in the recharge to the groundwater table through occupation of a recharge area such as that in the southwest portion of the region through decreasing infiltration because of impervious cover, and through elimination of agricultural irrigation in the area. Development tends to increase the peak rate, volume and frequency of flooding both within and without the floodplain. The extent of increase tends to be larger for the more frequent floods than for rarer ones. These changes can cause greater erosion within steep floodplains and may affect the vegetation that can be maintained.

Development is likely to produce a decline in water quality reaching the hydrologic features. This can result from automobile wastes, fertilizers, pesticides, sewage and sediment. Poor water quality greatly speeds up the natural eutrophication process of lakes and can affect the flora and fauna of lakes, wetlands/marshes and floodplains.

The various hydrologic features such as floodplains, lakes, groundwater, or marshes can also affect development. Any floodplain development can be unwise, particularly along those stretches of the upper portion of Bear Creek, Clear Creek and the upper portion of the South Platte River which experience periodic flashflooding. The aesthetic quality of lakes may provide the interesting focal points around which developments are planned. A reliable groundwater supply may be one consideration in the feasibility of particular developments. Wetlands/marshes within the study area are generally not viewed as assets but may affect development through creation of the need for drainage projects to dry them up.

Biology

The conversion of rural lands to urban uses typically requires flood control measures for local watercourses. Channel straightening, removal of reparian vegetation, paving of streambanks and colonization by weeds severely reduce habitat diversity. The soils erosion impacts discussed earlier affect aquatic habitats by filling in rough stream channel bottoms with silt which eliminates the physical niches necessary to benthic organisms, thus eliminating the organisms themselves. Continuing and future aggregate mining necessary to construction activities is likely to entail channel disturbances and modifications, streamside vegetation removal, and discharges of wash water from gravel processing operations. Construction across riparian zones severs the continuity of this habitat thereby disrupting wildlife movements through it. Development around pond and marsh areas often disturbs the local habitat quality. The opening of rural and wild lands for residential and increased recreational uses creates pressures on wildlife and their habitats.

Development along the foothills and mesa areas may infringe upon critical wintering areas typically used by deer and elk. Some curtailment of deer and elk feeding range may occur in the eastern boundary near Cherry Creek Reservoir and to the west in Douglas County. Animal and bird migrations through the lower foothill area may also be disturbed. As indicated on Map F, several areas have been recognized as ecologically significant due to unique geologic formations, soil types, plant and animal communities and other factors. Development and recreation pressures on these areas may not only degrade the habitats or affect the surrounding environments, but which also cumulatively reduces the overall environmental quality of the region. Areas of particular concern due to urban expansion as noted by comparisons of the Projected Land Use By the Year 2000 Map (Map I) against the Biologically Sensitive Areas Map (Map F) are: (1) the Nature Conservancy in northwest Denver, (2) the Ken Caryl-Johns Manville Ranch, (3) the Marshall Mesa and (4) the White Rock area near Boulder.

Human activities greatly increase the wildfire potential particularly on slopes of 30 percent or greater where the fire hazard is critical. Construction and maintenance activities on steep slopes and the resultant slash, felled trees and other inflammable litter significantly increase this potential.

Energy

The 1975 population of the Denver Region constituted about 57 percent of the population of the State of Colorado. By 1985 it will constitute perhaps 60 percent, and by 2000 about 54 percent of the state population. The Denver region's share of statewide energy consumption is estimated to be on the order of 64-68 percent at the present time. Natural gas shortfalls, amounting to 15-20 percent within five years, are expected to begin in the Denver region during 1978-79. The demand for natural gas by the Denver region may adversely affect the rural areas of Colorado as rural areas are dependent on liquid propane which is manufactured from natural gas. There will be an increased reliance on and demand for electric power. After 1980, if scheduled power plants are delayed significantly, some brown-outs or load reduction and shedding will occur. The increased demand for electrical power will probably be met with coal-fired power plants which will necessarily increase Colorado's coal production. Consequently, beginning in the 1980's, conflicts will arise between municipal and agricultural water users in the Denver region, and energy industries over available water supplies. Adverse air and water quality impacts are also likely. Reference 970.

Regional demand for petroleum-based fuels will increase with increased population. This increased demand will be limited to some degree by increased vehicle fuel economy and higher fuel prices. Although there will still be a net increase in consumption, petroleum-based fuels will be a smaller part of overall basic fuel use.

Aesthetics

Growth in the Denver region could lead to a degradation of many qualities which have created Denver's attractiveness and desirability. Some of the qualities that would probably be adversely affected include: (1) open spaces, wetlands and other natural areas, (2) wildlife, (3) scenic views through high-rise construction and air quality related visibility obstruction, (4) air quality, (5) noise levels, and (6) relaxed lifestyle.

Outdoor Recreation Sites

Regional growth will require development and recreation sites beyond those acquired to date. The growing needs of populace will not be met as the land area per capita for parks will decrease 36% from 15.2 acres per capita in 1970 to 9.9 acres per capita in 2000. Park overuse and facility vandalism will continue and intensify throughout the region particularly in those areas having a high percentage of children and young people. This will be especially true in new suburban areas where there is a general predominance of young families. As these suburban areas age, the populations should begin to mature and the incidences of vandalism should somewhat decrease.

Land Waste Treatment Sites and Wastewater Reuse

Until a decision is made on the West Adams County Sludge disposal site, the Lowry Bombing Range sludge disposal activities will continue and existing problems could worsen due to the high sludge application rates. However, the anaerobic digesters now under construction at the MDSDD No. 1 plant will reduce the short-term possibility of a worsening situation. If the West Adams County site is not approved due to some unforeseen environmental or legal problems, some new disposal scheme for the Lowry site might be adopted which could continue the present controversy. This controversy has resulted from a basic conflict between the established disposal use and the adjacent and growing residential uses.

As was indicated in an earlier chapter discussions, development of new land application systems for wastewater treatment under the ownership and operational control of Denver area sanitation districts is considered difficult. Monitary costs of land acquisition and water rights problems have made these systems look unfavorable by comparison to conventional treatment. In some cases the wastewater operating agencies (e.g. Metro) do not have ownership of the waters they are treating. However, implementation of a Metro-operated land application system presents innumerable institutional difficulties.

Development of new lands for irrigation also run afoul of existing water rights. For a municipality owning tributary water, a land application system that consumed additional South Platte water, would require the purchase of additional water by the municipality to "make up" the lost consumed water. Cities that own West Slope non-tributary water do generally have the right to reuse the water.

From EPA's perspective, water quality benefits are paramount, especially where potential construction grant funding is involved. From the point of view of the municipalities, the most financially beneficial use of these waters and development of new domestic water supplies may be the most important criteria. From the perspective of downstream irrigation, water supplies should be neither diminished in quality or quantity. Additionally, State water quality priorities have favored protection of high-quality mountain streams (much of which is on the Western Slope) over plains streams that vary widely in seasonal flow and have been heavily contaminated by municipal and agricultural use. Thus, defining "benefits and impacts," particulatrly for water quality is no easy task.

A number of important interrelated considerations must be kept in mind in discussing reuse potential in the water-short Front Range area:

a. The region is still growing rapidly in population. Considerations of new municipal water supplies for growth is necessary.

b. All of the water now in the South Platte basin is being used; in fact, successive use is the rule downstream to the Nebraska border.

c. New supplies of water can come from the West Slope only from trans-basin diversions. Municipal water supply for new growth can come either from this source or by condemnation or first use of agricultural rights.

d. Stream quality in the Front Range is degraded from municipal, industrial point source, and non-point source runoff from urban areas and agriculture. Reuse schemes must be viewed in the context of both instream water quality and quantity.

Section III identified three possible reuse schemes. A subset of the recycling scheme would involve reuse of water by industry or for urban irrigation (e.g. golf courses.) An evaluation of the environmental merits of the four potential reuse schemes is given in the list below. For comparison purposes all four schemes assume a doubling of population and water use in the municipality. All comparisons are from a base case of the present situation with limited reuse.

1. No Reuse

   - Increase in the environmental effects of West Slope diversions and/or condemnation of South Platte rights.

- AWT needed to meet standards or the total load of ammonia and nutrients to the streams will increase.
- Flow downstream will be augmented.
- TDS concentrations downstream decreased; total load increased.

2. Agricultural Successive Use

   - Increased effect of West Slope diversions and/or condemnation of South Platte rights.
   - Stream quality below outfall improved (TDS and nutrients decreased) during irrigation season.
   - Ammonia nutrient benefits to agriculture.
   - Smaller AWT plant may be required.
   - Potential public health effects and soil damage

3. Water Exchange - "First Use" by municipalities

   - No additional effect on West Slope streams or from irrigation water rights condemnation.
   - Stream flow between water supply diversion and wastewater plants reduced.
   - Nutrient benefits to agriculture.
   - Offstream storage may be required.
   - Higher TDS and lowered flow downstream.
   - Potential public health effects and soil damage.

4. Increase by Recycling

   - No Additional effect on West Slope Streams or from irrigation water rights condemnation.
   - Higher TDS in City drinking water
   - Possible other contaminates in drinking water.
   - AWT Plant for Reuse and Discharge Required.
   - Higher TDS and Lowered Flow Downstream.

It is apparent in this analysis that no one system has an absolute advantage over another. Total costs have not been evaluated for such alternatives. There will be environmental benefits and impacts with any system.

System No. 1 has the advantage of providing more flow downstream to the agricultural community. In such a system however, the owners of the imported water would have to receive compensation from potential downstream users for added water. West Slope streams would suffer the environmental impact of stream depletion.

System No. 2 has similar benefits and costs to system 1 except that stream quality in the vicinity of the municipality and immediate downstream would be somewhat improved.

System No. 3 has the advantage of no additional importation or condemnation of water rights. Nutrients are diverted from the stream in favor of farms. TDS values in the stream may increase however and stream flows within the vicinity of the municipality may be depleted.

System No. 4 involves no new or condemned water, but adds TDS and possibly other contaminates to the municipal drinking water. Alternatives to this are more expensive advanced wastewater treatment. Downstream flows are also depleted and TDS is increased.

Complications of real life situations can confuse this idealized analysis. In many cases, the depletions, nutrient removals and TDS increments changes are small in comparison to the total water quality problem. Such systems may only marginally change water quality.

Exchanges can be complicated if some other higher use is made of canal waters (e.g. Barr Lake -- an irrigation storage reservoir contemplated as a recreation area).

West Slope diversions are generally not made on an incremental basis. Reuse schemes like 3 or 4 may be made in conjunction with large, capital-intensive West Slope diversions (e.g. Foothills and reuse projects of the Denver Water Board).

Protection of agricultural uses near the metropolitan area may not necessarily be safeguarded by "first use contracts." The decision to retain farmland in agricultural use near a metropolitan area is basically economically constrained. If the price of farmland conversion to urban uses is high enough or if costs of operation (taxes, distance from marketing areas) of farms gets too high, farmland will still be converted. Given the same amount of water available for agricultural uses, new farms or expanded farms farther away from the metropolitan area may compensate for farmland lost around the metropolitan area.

Advanced waste treatment to remove NH_3, chlorine, and phosphates is not now practiced in the Denver metropolitan area to meet 1983 goals. A commitment to removal of these substances will be an expensive proposition. The value of any of the reuse schemes must be related to the most cost effective method of achieving these results. Although the State of Colorado has classified most Front Range streams as B-2 (warm water fishing, secondary contact recreation), funding has not heretofore been available for advanced waste treatment. Should the State determine that future funds will be used to remove ammonia, chlorine and possibly phosphate, reuse schemes could prove to be a cost-effective method of attaining water quality goals. However, adequacy of flows and stream habitat do limit the fishery potential in many streams in the Denver region. With certain reuse schemes which may improve water quality, stream flows may be further depleted. Therefore, both water quality and quantity must be considered in determing impacts of reuse on proposed stream uses.

Traffic

Impacts related todependence on the automobile such as low density or sprawl development, congestion and high noise levels in the central business district (CBD) will continue to worsen as the region grows. The situation of the commute-hour traffic overload on the region's highway system will continue and in some areas such as the CBD and suburbs near the CBD it will become worse. New highway construction to alleviate existing traffic problems will compound the situation by providing additional highway capacity which can accommodate more growth and its traffic. Further suburban growth would absorb the new capacity in a relatively short period of time. The Federal Urban Mass Transit Administration's denial of funds for a regional transit system eliminates the possibility of a fixed rail system for the present time. Any regional transit system proposed by the Regional Transit District (RTD) to compete with the automobile will have to rely on RTD's fleet of buses.

Such things as carpooling and vanpooling will reduce the number of cars on the road by increasing the average number of people being carried in each vehicle. The Regional Transit District has a bus system which provides a good alternative to travel by automobile only. A fixed guideway type of facility has been studied in an alternatives analysis and has been shown to be no more efficient in attracting people from their autos than a comprehensive Regional Transportation System comprised totally of buses.

DIRECT ENVIRONMENTAL IMPACTS

Climate

Construction activities are generally restricted during Chinook events which are temporary in nature and occur primarily in the winter when little heavy construction is done, thus minimizing effects upon construction. Wastewater treatment processes involving spraying, such as trickling filters and irrigation of effluent may produce local aerosols containing microorganisms and dissolved solids. During Chinooks, these aerosols could be carried long distances. Some damages to physical property suffered during high-wind occurrences which would result in temporary, higher energy and cost requirements as repairs are made. Blowing particulate matter from spray operations and sludge disposal sites may impair vision and impede transporation.

All land application methods, including percolation ponds, will affect the local microclimate. Volatilization of water molecules may lead to a local fog formation during certain periods and produce a nuisance effect. Such an effect could take place at the proposed sludge land application site for Metro Denver which is located close to the proposed Adams County general aviation airport (Reference 126) causing costly delays in terms of time and manpower.

Low-temperature conditions can limit biological processes and thus curtail certain treatment processes such as aerobic digestion, trickling filter systems, and mechanical aeration.

The Littlefield/Englewood, South Lakewood, South Adams, Aurora, and Metro plants have the highest potentials for odor problems on still days. The proposed satellite plant on Cherry Creek may have odor problems if future residential development occurs nearby.

Hydrology

The construction and operation of wastewater treatment plants can have important impacts related to the drainage network in the study area. Plant siting can affect the water supply for the reach below it by defining the point of return flow for the municipal water system. Since both irrigation and municipal water systems use the drainage network for most of their supply, the point of return flow of domestic water can be critical. Plant construction and plant operation and maintenance will affect the water quality in the drainage networks as discussed previously in the discussion of water quality. Better water quality may decrease the level of treatment for municipal systems and may even affect the quality of crops irrigated with the water.

Siting of those projects to be undertaken within floodplains requires special consideration. They must be designed so as not to increase the potential for flood damage either upstream or downstream. Since facility damage may result in direct release of untreated or partially treated sewage, the facilities must also be capable of withstanding the flood depths and velocities to be expected. Several interceptors such as Sand Creek as well as the central plant expansion of the Metropolitan Denver Sewage Disposal District No. 1, the Lower South Platte, and Cherry Creek satellite plants, will be sited in floodplains.

Interceptors that will be aligned through wetlands/marshes such as the proposed Sand Creek interceptor may cause adverse effects. The trench excavation and the pumping to keep it dry during construction will lower the groundwater table and may temporarily dry up the marsh. If gravel is used to backfill part of the trench, it could act as a drain to lower the groundwater table permanently. On the other hand, any leakage of sewage from the interceptor might adversely affect the quality of the water in the marsh.

Geology

No significant direct alteration of land forms is anticipated through implementation of any of the alternatives. No significant direct impacts of geologic hazards or on unique and significant geological formations or structures are anticipated for any alternative.

Soils

Soil-related direct environmental impacts result almost exclusively from construction activities. These impacts consist of water erosion from construction sites and commensurate temporary surface water quality degradation. Wind erosion of exposed soils results in windborne dust and particulates. These effects are generally temporary or of short duration. The local alternative would cause the greatest amount of these type of impacts, the regional alternative the least, with the no-action alternative causing impacts more similar in magnitude to the local alternative. No alternative would cause significant adverse impacts.

Biology

Direct Impacts of Local Alternative--

The identified alternatives would not significantly reduce flora or fauna in the Denver metropolitan area. In general, the treatment plant sites and the interceptor corridors do not support native plant commities. Rather, each of the sites proposed for wastewater treatment facilites is usually typified by introduced vegetation and wildlife species tolerant of human presence. All of the facilities are situated either in urban areas or areas traditionally supporting agriculture and grazing activities. Three types of potential impacts upon biotic communities have been identified. The first two relate to construction activities while the last one concerns facilities operations.

Disturbance or Loss of Vegetation and Wildlife Habitats--New treatment plant facilities and interceptors would be constructed for the following service areas: South Adams, Englewood/Littleton, Cherry Creek/Goldsmith Gulch, Lower South Platte, Clear Creek/Sand Creek, and Broomfield/Westminister. Site construction would entail the removal of ground cover and reduction of habitat for some small animals. Principal plant cover in adjacent areas would remain relatively unaffected. No losses would be anticipated for highly productive habitat or rare and endangered plant or animal species. The main differentiation regarding impacts on vegetation and wildlife which can be made between the various facilities plans is related to the size of the facilities and subsequently the amount of flora and fauna that would be removed.

Disturbance of Aquatic Habitat during Construction--Treatment plant construction adjacent to watercourses could cause short-term disturbances to the aquatic environment. Facility sites with potential effects on aquatic systems are Big Dry Creek, Lower South Platte, and Clear Creek and Englewood/Littleton. Other facilities will probably use existing outfalls or convey effluents to a regional facility. Removal of riparian vegetation could increase erosion and adversely affect water quality and aquatic habitat. Increased turbidity and sedimentation will disrupt bottom habitat, kill invertebrates and degrade water quality. These effects on the aquatic environment would be a short-term adverse impact for up to several thousand feet downstream of the facility. Physical stream conditions would be restored by the natural scouring and restoration effects of spring flows or seasonal upstream releases.

Effects upon Aquatic Environment during Facilities Operations--All of the proposed facilities would improve local water quality within the Denver area. The South Platte River would benefit from higher quality effluent discharged by the Englewood/Littleton, South Adams and Metro Central Plant facilities. Big Dry Creek would receive surplus flows from the Broomfield/Westminster facility.

This improvement in water quality would enhance productivity of the aquatic environment and, through the food chain, would also enhance productivity of the terrestrial environment. The resulting greater carrying capacity of these ecosystems could likely increase the number of individuals supported in the area. The potential for establishing species not presently supported in these reaches of San Creek, Clear Creek, Big Dry Creek and the South Platte River is likely to have both beneficial and detrimental ramifications. Overall, the multiple discharges provided in the local alternative offer the opportunity to increase habitat areas and promote a diversity of plant and animal species in the aquatic environment.

Direct Impacts of Regional Alternative--

The regional alternative, in general, would have fewer direct impacts than the local alternative due to the limited number of facilities. Potential impacts can be divided into the terrestrial environment of the facilities sites and the aquatic environment affected by the treatment facilities.

Disturbance or Loss of Vegetation and Wildlife Habitats--Construction of new facilities will be limited to the Englewood/Littleton and Metro (MDSDD #1) treatment plant sites. Interceptor routes that will be constructed through vegetated areas include portions of the Lower South Platte drainage course. Other interceptor routes will follow established roadways. Impacts of biotic communities would be similar to those discussed under the local alternative.

Effects upon Aquatic Environment--The regional alternative consolidates all wastewater flows, except Englewood/Littleton and Westminster/Bloomfield, to the Denver Northside and Metro Central plants. With the abandonment of local treatment plants, stream areas will benefit from the termination of local discharges high in BOD, suspended solids, ammonia-nitrogen, chlorine and other pollutants. On the other hand, diversion of effluent discharges would reduce local stream flows by 2-10 mgd. This would have a noticeable effect on smaller watercourses such as Sand Creek and Big Dry Creek where diminished flow reduces the amount of aquatic habitat. In comparison with the local alternative, the greatest number of discharges (including reuse) would have the greatest benefit to the natural environment through enhancement of the water regime.

Direct Impacts of the No-Action Alternative--

The no-action alternative embodies the same facilities as the local alternative. Impacts relating to the disturbance or loss of vegetation and wildlife habitats and the disturbance of aquatic habitats during construction are similar to those discussed in the local alternative section. The main impacts of this alternative are the effects caused by delays in project implementation.

Effects upon Aquatic Environment--One to three year delays in project implementation will require the continued use of local treatment plants and discharges to local streams, but eventually the beneficial impacts will approach but not equal those expected under the local alternative. The perpetuation of water quality problems presently experienced in some stream segments will be a short-term impact lasting an additional one to five years. Ammonia-nitrogen and chlorine residual, which in excess concentrations are toxic to aquatic life, are the parameters of significant concern to the South Platte River from the South Adams and Englewood/Littleton facilities and to Sand Creek near the Aurora facility.

Energy

Estimates of the energy consumed in the construction of facilities described for each alternative are not available. However, a limited comparison between alternatives is possible. Three factors can be considered. These are the total length of installed interceptors, the number of plant expansions and/or upgradings in treatment levels, and the number of new plants constructed under each of the three alternatives during the next five years. Assuming one unit of energy per mile of interceptor, one unit per mgd of plant expansion, and one-and-one half units per mgd of new plant capacity; a comparison of construction energy demands indicates that the local and regional alternatives are essentially the same. The no-action alternative construction energy demand would be about 20 percent less for the five-year period. As the no-action alternative includes delays in construction beyond the five-year period considered in this comparison, not all the reduction in energy demand would be realized.

Energy use during operation of the facilities will be dominated by the wastewater treatment plants themselves. First order estimates of the increase in natural gas and electrical power yearly demands of the alternatives five years hence are:

	Local	Regional	No-Action
Natural gas, million cubic feet	40	30	8
Electric power, million kilowatt-hrs	11	9	3

In this instance, the local alternative will result in the highest increase in energy demand. The significant qualities of natural gas demand for the local and regional alternatives are of particular concern as shortfalls in natural gas supplies for the Denver region are expected for the 1978-79 heating season. As wastewater treatment plants should be considered as interruptable consumers of natural gas, loss of process heat is a real possibility. Plant effectiveness would be degraded with consequent deterioration of effluent quality during stream low-flow periods. Stream or receiving waters' water quality could therefore be significantly affected.

Transportation

Direct impacts are construction-related and thus of a temporary nature. These impacts relate to disruptions of traffic flow near construction sites, and are likely to be greatest for the local alternative, somewhat less for the no-action alternative, and least for the regional alternative. No significant adverse impacts are anticipated.

Historical and Archaeological Features

Although no individual wastewater treatment plant would cause the removal or destruction of a designated historical landmark, some of the sites are near designated landmarks or in historical areas. The South Platte River valley, downtown Denver and Cherry Creek vicinity are areas of great historical interest; new interceptor lines will pass through these areas and the other creek basins as well in the regional alternative. Although historic sites having potential for official recognition as well as currently designated ones are not directly threatened by construction activities, they could be damaged structurally by such construction techniques as blasting and trenching. Hauling off construction material past historically significant points during the construction phase of one to two years duration could cause accumulative vibrational effects, but only in a very localized corridor along construction routes. Vibrational effects of hauling are of much smaller effect than actual pipeline excavation. Depending on the depth to bedrock or impervious layer and other factors, carving or blasting may be required along limited segments of the interceptor routes. Facility planning in the current planning stage has not determined the exact alignments. As excavation impacts are generally localized within approximately ten feet on each side of the trench, it would not be appropriate, and perhaps misleading, to project impacts over large areas until such information becomes available. The effects of dust and dirt raised by construction activities upon historic sites would also be minimal and difficult to predict at this time.

Archaeological information is not avialable in published form. Site reports have been obtained from the Colorado State Archaeologist and are in the process of being mapped for inclusion in the final EIS.

Outdoor Recreation Sites

Very few current recreation sites will be directly affected by construction of the proposed wastewater treatment facilities under any alternative as few new plants are planned. More new facilities are incorporated in the local alternative than in the regional alternative, thus potential impacts of the local alternative are greater. Water-based recreation plays a major role in Denver. Many recreation sites are located adjacent to or surround streams, lakes and reservoirs. As wastewater treatment facilities are to be located at points along these streams and several interceptor routes have been planned to lie adjacent to stream beds, some conflicts in siting may arise. The

Bureau of Outdoor Recreation (BOR) has identified some possible areas of conflict along Sand Creek, Clear Creek and the Lower South Platte drainages and has recommended that multiple use of land be a planning goal. A recreation plan is being developed for the Sand Creek-Tollgate stream corridor as a segment of the Corps of Engineers' Denver Metro Study. The proposed interceptor right of way would be a good location for hiker-biker trails to connect with those of the South Platte River Greenway. The proposed Clear Creek treatment plant location could be a potential recreation site. Either alternative could incorporate a trail system similar to that of Sand Creek. For the Lower South Platte, the BOR has identified in the Denver Metro Study (Reference 126) that a new wastewater treatment plant at 164th Avenue may conflict with a potential recreation site.

Stream flow will be augmented through treated discharge at many points in the local, new plants alternative, rather than at a few plants in the regional and no-action alternatives. The BOR has identified four areas of recreational benefit and potential resulting from new plant operation:

1. Return of a steady water flow to the Sand Creek, which could increase recreation benefits for hiking, bicycling and nature study. This would not occur under any of the current alternatives.

2. Return of water flow to the proposed Corps of Engineers reservoir to help maintain a conservation pool.

3. The use of additional open space acreage for certain kinds of recreation around the plant site.

4. Construction of certain components of the plant underground and utilization of the surface area for park and recreation purposes.

In addition, discharges of water of a relatively higher quality than the current stream flow will enhance fishery potential in areas not radically modified by channel improvements (see Map F), if the flows are high enough to sustain a fishery and if water quality is also sufficient to support a fishery. Increased flows will also enhance other recreational activities such as boating, contact recreation if health-related water quality standards permit, and general stream aesthetics, thus serving to enhance the quality of recreational experience obtainable at downstream sites. The more specific impacts on water quality and flow augmentation are addressed in the Water Quality section.

Two factors considered in the biological direct impact section have effects upon outdoor recreation: (1) the disturbance or loss of vegetation and wildlife habitats; and (2) the disturbance of the aquatic environment. In the local and no-action alternatives, seven new treatment plant sites and two new interceptor routes will permanently remove ground cover and reduce small animal habitats. This will reduce potential recreational opportunities in these areas. Although water quality will be enhanced by the addition of high-quality effluent, during the construction process disturbances such as erosion of banks and siltation of streams may extend up to several thousand feet downstream and last one to two years, thus impairing downstream recreational experiences. Those alternatives with the greatest number of discharges including reuse would have the greatest benefit to the natural environment and recreational experiences through enhancement of the water regime.

Land Waste Treatment

None of the proposed alternatives contemplate land percolation or infiltration as a wastewater treatment method. However significant reuse is planned where effluent would be used for urban or agricultural irrigation either directly or through exchange agreements. See Appendix A for details of future plans. Another motive for reuse, particularly through exchange agreements, is to secure additional water supplies for domestic or industrial use. Irrigation reuse is also attractive as discharges to streams are reduced with usually beneficial effects on stream water quality.

Crop irrigation with wastewater effluent, of the quality expected from proposed facilities, is generally restricted in the United States although more common in Europe. Use for irrigation of crops for direct human consumption is generally prohibited. The reasons are based on unknown risks of contamination by pathogens (bacteria and virus), mutagens, and carcinogens. Other concerns are buildup of salts in soils reducing productivity, buildup of heavy metals and chlorinated hydro-carbons in soils and subsequent uptake by plants, and eventual contamination of ground waters. Thus, unrestricted reuse for agricultural irrigation is not feasible without accepting the risks and impacts of such practices.

Aesthetics

Direct impacts on the visual and aesthetic environment can be divided into construction effects lasting only a short term and operation effects which entail both short- and long-term impacts. Similar types of effects occur within the local, regional and no-action alternatives. Differentiation between alternatives basically relates to the amount of area disturbed by the individual facility sites.

Construction Effects--

Adverse effects on local aesthetics during construction are generally related to nuisance factors. Pipeline excavation and treatment plant site preparation entail earth-moving, grading and, in some cases, dewatering. Depending upon seasonal and topographic conditions, the generation of suspended particulate matter is unavoidable. Construction noise, engine emissions from heavy equipment and vibrations are other nuisance effects. Traffic rerouting, temporary stockpiling of materials along roads, and increased truck traffic during construction period constitute temporary inconveniences which will require residents to make short-term adjustments.

Operation Effects--

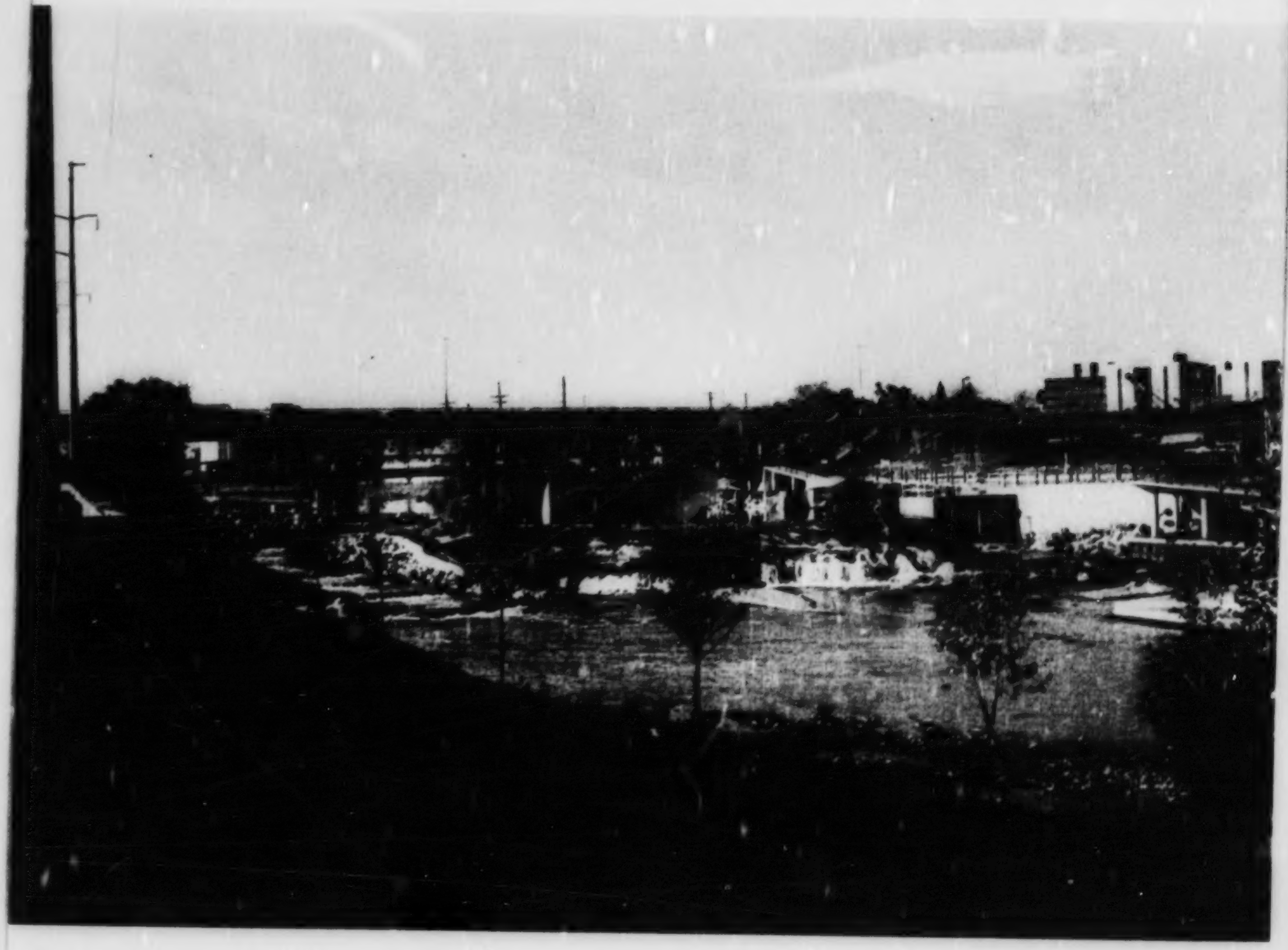
The local alternative with multiple treatment facilities would tend to have a greater odor, noise and visual impact than the regional alternative. The construction and operation of a treatment plant would certainly be intrusive and would tend to alter the character of the surrounding area. The structural facilities can be located away from areas of high visibility and designed to be visually and aesthetically compatible with the environs. However, plant operations will entail equipment noise, processing odors, incidental lighting and traffic from maintenance vehicles to some degree. Facility sites creating the greatest disturbance would be those closest to residential or commercial developments. Thus, expansion of the Aurora plant, the proposed Clear Creek plant, and the South Lakewood plant may cause some conflicts.

Facility plans which incorporate some system of treatment or disposal by land application would be more land-intensive than structural treatment systems. Land application probably would not be noticeable as a distinct and separate land use within an agricultural community. However, potential odor problems during adverse conditions may affect a larger area than that of a small physical plant.

In an overall evaluation, the improvement of wastewater treatment in the planning area strives toward obtaining and enriching cultural goals such as recreation, ecological viability and aesthetic enjoyment. These are presently fulfilled in the mountain parks and streams west of Denver. For the plains streams, however, improvement in water quality alone will not fulfill those goals. Hendricks and Bluestein (Reference 982), in their study of the South Platte River, concluded that:

> "Their achievement is essentially precluded by the modifications brought about by intense human uses of the stream and associated lands and by the natural characteristics of the plains streams. Thus, improvement of water quality in the plains South Platte to 1983 levels (as specified by PL 92-500) will result in few benefits and at very high costs. However, to permit deterioration of the mountainous South Platte will result in irrevocable societal losses. From all of

this, it would seem that the most cost effective investment policy would be to protect the mountainous South Platte from deterioration and to maintain the plains South Platte to permit continuance of exisitng human activities."



V. Mitigation of Impacts

SECTION V

MITIGATION MEASURES

The significant adverse impacts identified and assessed in Section IV are further examined in this section to determine the means by which they may feasibly be avoided, eliminated or minimized. This examination is divided into six categories of major interest: growth impacts, air quality, water quality, energy, growth-induced impacts and direct impacts.

A number of the mitigation measures evaluated in this section will address regional land-use impacts over which EPA has little direct authority. No attempt has been made to limit evaluations of mitigations to only those which EPA has the authority to implement. This approach has been taken because of the nature of regional water quality and related problems, which have been created in a framework of overlapping jurisdictions and which must be solved to a great extent within that framework. It is necessary for EPA and other concerned parties to understand to what extent water quality and other environmental problems may be solved through EPA's direct efforts and to what extent it must rely on other governmental bodies. The results of this approach have raised or amplified issues regarding the adequacy of existing air quality, water quality and land-use regulations operating in the Denver region. This section is intended to stimulate discussion and debate by decision-making bodies, responsible agencies and the general public on desirable ways to remedy the impacts assessed in this EIS.

MITIGATION MEASURES FOR SOCIO-ECONOMIC IMPACTS

Socio-economic impacts rarely lend themselves to straightforward mitigation. Due to their complex causes and consequences, simple, short-term remedies cannot always be prescribed. Generally, less direct and more costly long-term program solutions are recommended. The overall effectiveness of mitigating programs is too variable to predict because of various limitations such as inadequate enabling authority, staffing and budgets which are too often placed on individual programs. Yet, even with adequate authority, staffing and budgets, there can be no guarantee that a given program will be effective. Some socio-economic problems simply cannot be solved by funding new programs or reorganizing existing ones. Thus, the implementation of the mitigating programs mentioned below may or may not be reasonably successful in avoiding, eliminating or minimizing the socio-economic impacts assessed in Section IV. These mitigations will require further consideration and study by the Denver region's governmental agencies and by the general public before any concensus can be reached as to their appropriateness and desirability.

The following discussions on various types of mitigations present a number of steps that could be taken to improve the effectiveness of planning in the Denver region. Those listed below arose frequently in discussions with local planning officials but are by no means an exhaustive inventory.

Reduce the Number of Special Districts

The proliferation of special districts has created numerous problems in coordinating capital facility planning and in assuring reasonably similar levels of cost for similar levels of service throughout the region. Some of the suggestions made were for the formation of a regional services agency (Reference 1044); another was that the municipal government should assume all special service functions (Reference 1045).

Establish a Formal Environmental Review Procedure

This might take the form of a state or regional environmental review agency, as suggested by Adams County Planning Director Robert Fleming (Reference 1046), or it could be modeled on the environmental protection legislation of other states. Such "mini-NEPA" laws open decision-making on private and public project proposals to public review before discretionary action by local government and thereby permit citizen review of and comment on private development proposals. Environmental review procedures under the National Environmental Policy Act of 1969 (NEPA) apply only to federal actions and actions involving federal interests.

Establish Regional Land Use Planning for Major Uses and Natural Resources

The development of major types of land uses (such as large industrial establishments) could be made subject to review and approval by a regional agency which could take into consideration the locational requirements of major uses and the broad environmental concerns of the region as a whole in a manner local agencies cannot. Empowering such an agency to review major industrial and transportation related development decisions could help the region move toward greater integration in planning for all kinds of uses. Such an agency might be able to protect agricultural uses and environmentally sensitive areas more successfully than local governments can.

Move Toward a System of Regional Tax-Base Sharing

Reducing the fiscal rivalry which distorts both community land use patterns and industrial location decisions could be accomplished under a program of regional tax sharing. Such a system, like that developed for Minneapolis/St. Paul, might begin by sharing only the increase to assessed valuation arising from new development; this initial step would be more acceptable than an across-the-board tax sharing plan, which would wipe out the fiscal advantages many communities have assiduously striven for through years of planning. However, even the sharing of the assessed value increment would go far to reduce rivalry for tax base and permit other kinds of development criteria, including environmental criteria, to carry more weight.

Establish a Fiscal Cost/Revenue Balance as a Condition of Development Approval

The citizens and officials of a community often make decisions on development proposals without knowing if the revenues generated by the development are in balance with the costs required to provide municipal services. When costs are significantly and consistently out of balance, inefficient development patterns usually result. The establishment of policies will require the development of methods of determining fiscal costs and revenues to a municipality. The DRCOG could provide assistance in developing such policies and methods which must recognize that other economic and social considerations may override the goal of balanced costs and revenues.

Accelerate Development of Parks and Recreation Sites

The forecasted decrease in the per capita recreation area within the region and the associated adverse impacts can be mitigated if local agencies developed and implemented plans to acquire and develop recreational and park sites in the Denver region. The aggregate amount of land that needs to be developed is about 400 acres a year for the next several years to maintain existing park density.

Discourage Growth in the North and Northeastern Portions of the Denver Region

About 75 percent of the agricultural land, including 85 percent of prime agricultural land, forecast to be lost to urbanization by the year 2000 is located in Adams, Arapahoe, and Boulder counties. Over half the prime agricultural land expected to be lost is located in Adams county. By not providing grant funds for capacity expansions of wastewater treatment facilities in Adams County and the plains portion of Boulder county, growth may be slowed in these areas and redirected to other areas of the Denver region. Growth is supported by other urban services, as well as by wastewater collection and treatment. Therefore, the effectiveness of this mitigating measure will be limited unless supported by coordinated federal, state, and local government policies.

MITIGATION MEASURES FOR AIR QUALITY

As described in greater detail in the Probable Impacts Section and reference 998, National and State air quality standards will continue to be violated in Denver over at least the next decade and probably the next 25 years. This result includes the probable emission reductions attributable to the Federal program for control of vehcile emissions as well as existing industrial stationary source controls and State particulate control regulations. Predictions indicate that carbon monoxide (CO) concentrations will exceed the 8-hour standard in some portions of the Denver region through 1985, and "hot spot" concentrations will probably continue to exceed standards through the year 2000. Ozone (O_3) concentrations will continue to violate the National standard in 1985, and by 2000 will be reduced to concentrations nearer but exceeding the standard (.08 ppm) for the assumed meteorological conditions. Nitrogen Dioxide (NO_2), which is not presently recorded to be in violation of the annual standard, is expected to decrease in concentration in line with the expected reductions in ozone. Particulates which presently greatly exceed the air quality standards are predicted to get worse through the year 2000.

As previously indicated, these air quality predictions assume certain emission controls, which presently exist and are administered by the State of Colorado for industrial type sources and certain particulate sources along with projected vehicle emission controls, but do not include all technically feasible control measures. In addition, these results assume and are based on the regionally adopted year 2000 transit, highway and land use plans. Of concern to EPA in mitigating these air quality impacts, is what strategies and/or plan changes may be most effective in reducing pollution in Denver, both in the near term and over the next several decades. Once identified, the question becomes how might the implementation of these mitigating strategies or plan alterations be encouraged by EPA's decisions on the funding wastewater treatment and conveyance facilities and on the recommendations of the Clean Water Program (Denver 208 plan).

The following discussions explain the implications of certain changes in the stated assumptions which were used to predict the probable air quality impacts. The results of these changes on air quality forecasts can be used to make certain inferences about the mitigation potential of future land use, population, vehicle usage, and emission control decisions. Therefore, the investigation of the assumptions made regarding land use, transportation, etc., provides information on the sensitivity of the air quality modeling results to these assumptions, and the potential for changes in regional development and transportation plans and implementation of pollution control strategies to improve Denver's air quality.

Mitigation of Growth-Related Air Pollution Emissions Through Land Use Control of Development Patterns

To aid EPA's decisions on requests to fund construction of additional capacity in wastewater facilities, it is important to know not only the consistency of regional development plans with air quality goals, but also the potential for reducing air pollution through future land use modifications. Therefore, an analysis was undertaken to ascertain the potential for changes in pollutant concentration and distribution which could be expected if the population growth patterns in the Denver Metropolitan area were to be changed.

Outlying areas which were considered to be subject to relatively high growth rates were divided into six areas, each with comparably equal projected population growth. These areas were named: 1) Broomfield/Westminster/Arvada; 2) Northglenn/Thornton; 3) Aurora: 4) South Metro; 5) Urban Jefferson County and 6) Lakewood. To simulate the air quality impact of a redistribution of population in different parts of the Denver region, several computer runs were made in each of which the year 2000 emission rates, in one selected area, was reduced by 25 percent, with this deficit in emissions redistributed to all other areas in proportion to their populations. Also a computer run was made in which the emissions within the Denver city limits were reduced by 17 percent and likewise redistributed to other growth areas. These perturbations were intended to represent larger, more isolated changes than might likely occur in the normal course of events, but at the same time recognize the existing urban form in Denver. This analysis was performed for each regulated pollutant. Air quality model runs for ozone were also used to determine the sensitivity of short-term carbon monoxide or nitrogen dioxide concentrations to this redistribution of emissions. Particulates and NO_2 annual averages were computed separately.

In spite of these changes in emission patterns, almost no detectable change in ozone concentration or distribution was computed. Differences between all simulations for ozone were confined at all times of day to at most 1 part per hundred million in one or two grid squares. This result is attributed to the time required for ozone production. By the time significant amounts of ozone has been formed, the emissions are too well mixed to reflect their origins. Since the formation of NO_2 from NO emissions follows essentially the same process as ozone. Short term NO_2 results were effected very little. It is reasonable to expect that very little difference in the annual average concentrations of this pollutant would result from a similar redistribution of NO emissions. Although a similar analysis was performed for CO, it is reasonable (due to the rather localized nature of CO pollution) to expect that CO "hot spot" concentrations would not be revealed. Critical intersections or parking lots would not necessarily change with growth of the community.

In the same manner as for ozone predictions, the sensitivity of annual average particulate concentrations to a redistribution in emissions was determined. The results showed that a 25% reduction in particulate emissions did not result in a 25% reduction in concentrations, but rather a 5 to 10% reduction in the vicinity of the reduced emissions. For non-reactive pollutants such as CO and particulates, ambient local concentrations are made up from both regional and local emissions. Therefore, a reduction in emissions locally will not result in an equal reduction in concentration due to the influence in regional pollutant emissions.

The results of this analysis indicate that region-wide control of pollutant concentrations is not achieved by a substantial redistribution of emissions. For particulates and probably CO, emission redistribution results in local reductions in concentration equal to some fraction of the local emission reduction. Thus, it would not appear to be fruitful to utilize, restrictive, local land use controls, which might promote development elsewhere, in order to relieve regional air pollution problems. Rather it appears that for ozone an overall reduction in emissions is needed and for carbon monoxide a composite emissions reduction in many local "hot spot" locations (i.e., major arterials, freeways, and intersections) should be pursued in land use and transportation planning.

It should be noted that the above discussion is based solely upon a redistribution of emissions not a reduction within the region. Changes in land use patterns towards much higher density may reduce total emissions through increased use of transportation modes other than the automobile and by producing more energy efficient living systems. However, without significant reductions in vehicle emissions or reduced use of the automobile, the exposure to high pollution levels, within these high density areas, could be even greater than presently forecasted.

Mitigation Through a Region-wide Reduction in Emissions

It is conceivable that with real changes in the expected future land use, population growth and the proposed transportation system for the Denver region, that an overall change in pollutant emissions will occur. This would result in a different picture of the future air quality than that described in the Probable Impacts Section. More people and greater use of the automobile than presently projected will result in worse air quality than previously described. However, this possibility is not discussed here since mitigation of the present and projected pollution problem is EPA's objective. Intuitively, a reduction in air pollution will occur if people drive less, and if less petroleum based fuels are used by stationary sources than now projected for the year 2000. However, it is not known to what extent decisions on the Federal, State, regional or local level might affect this new trend and secondly, what the exact effect would then be on the region's air quality. By making different assumptions about future population growth and transportation systems, and then determining the change in emissions, the change in air quality could be determined through modeling to answer the second question. Such an evaluation has not been performed. However, if a uniform reduction in emissions is assumed, from that presently projected, the resultant ambient air quality change can be determined. This type of simulation was performed to determine the effect of a uniform 30% reduction in emissions, on ozone formation. Such a reduction, regionwide is considered to be very significant, if attainable, and requires the implementation of all mitigative strategies such as parking controls and exclusive bus and car pool lanes, gasoline rationing, etc., to reduce vehicle miles of travel. It was found that a 30% uniform reduction in 1976 emissions resulted in approximately a 15% reduction in peak ozone concentrations in the region. Such a reduction in ozone concentrations would not result in immediate attainment of the ambient air quality standard. However, the ozone standard might be attained in about 20 years.

Probable Effects of an Automobile Inspection and Maintenance Program

A motor vehicle inspection and maintenance program will not eliminate the pollution problem in the Denver area, but it is a necessary first step in attacking one of its major sources. If passed, the proposed legislation will require, beginning January 1, 1979, the annual inspection and necessary maintenance of 1977 and later model year motor vehicles to help insure that their air pollution control systems work as designed. It is proposed that the inspection and maintenance program would work in much the same way as Colorado's safety inspection program. It is estimated that an inspection will cost around $5.20. When needed, maintenance may cost from twenty-five to fifty dollars. The program will not only reduce air pollution but will also result in gasoline savings through more efficient engine performance.

The exact impact on air quality of the proposed inspection and maintenance program has not been determined. In the Probable Impacts Section, the air quality impacts are discussed assuming the inspection and maintenance program is not put into effect, which is the present situation. In contrast to the air quality predictions given in the Probable Impacts Section, estimates of the air quality in Denver have been made assuming very strict compliance of automobiles with the Federally mandated auto emission limitations. In fact, strict compliance is not being achieved today and is not projected to even nearly being achieved in the future without some kind of inspection and maintenance program. This is due to the fact that: 1) manufacturers are presently not able to produce cars which meet all of the emission limitations; 2) a certain percentage of cars experience early failure of the catalytic converter (the principal emissions control device) and; 3) many automobiles are not properly maintained to meet the emission limitations and others are maladjusted. An inspection and maintenance program will greatly reduce the latter two problems in meeting the Federal emission standards.

Although not exactly the result of implementing an inspection and maintenance program, strict compliance with Federal emission standards would reduce carbon monoxide concentrations by almost 40 percent of that projected for 1985 in the Probable Impacts Section. Regionally, although not in all "hot spot" locations, adherence to auto emission standards would bring CO concentrations very close to the 8-hour ambient standard in 1985. For ozone the effects of properly controlled automobile hydrocarbon emissions would not be as great as for CO. Peak ozone concentrations would be reduced for 15 pphm to 13 pphm in 1985, a 13 percent reduction; and from 11 pphm to 9 pphm in 2000, an 8% reduction.

Possible Effects of a Relaxation of the NO Emission Standard

In a different assessment of the probable effects of changes in vehicle emissions, the impact on ozone and NO_2 concentrations of an increase in NO emissions (as presently proposed by the automobile manufacturers) was evaluated. This air quality simulation assumed a relaxation of the NO_x emission standard roughly corresponding to a proposal now before Congress to permit 1 gram/mile NO_x emissions rather than the 1978 goal of 0.4 grams mile. Results of this simulation for conditions otherwise the same as the 1985 probable impact results showed only slight violations of ambient standards for ozone and no increase in peak NO_2 concentration. With strict compliance with Federal vehicle emission standards, as discussed above, except for the proposed relaxation in the NO_x standard, no violation of the ozone ambient standards was predicted for 1985.

The reason for an improvement in air quality with increased NO emissions is that the ratio of the two ozone precursors, hydrocarbon and NO become unbalanced. Not enough hydrocarbon would be present to oxidize the NO to NO_2 to in turn produce ozone before atmospheric mixing and dilution lowered all concentrations. This result is specific to Denver's bad ozone days (3 August and 28 July 1976). Regions with other emission mixes or patterns and other dispersion climatology would probably experience different results. Specifically areas with more persistent inversion conditions will probably have a worse ozone and NO_2 problem if the NO emissions standard is relaxed. Therefore, as a National strategy the impact of relaxation of the NO standard has not been determined.

It should be noted that if the NO standard is relaxed this results in a larger NO plume coming from Denver. Any downwind area releasing hydrocarbons into this plume will experience large ozone concentrations because of the reaction with the NO_2 originating from Denver's NO emissions. Also, the predicted decrease in ozone concentrations in the Denver region would, of course, be accompanied by increases in NO concentrations. Although there is no Federal air quality standard for NO, (only an NO_2 standard), it is not probable that increased NO concentrations are desirable. NO does oxidize to NO_2 and NO_2 is regulated pollutant. Increased NO emissions do not necessarily lead to increased NO_2 concentrations in the Denver region for reasons similar to those explaining the ozone reduction. Increased downwind NO_2 concentrations could, however, be expected, because of the longer time available for the conversion of NO to NO_2. Thus, any proposal for relaxation of the NO emission standard as a pollution control measure must be done after a national account of potential downwind effects, for both ozone and NO_2, and the knowledge of the health effects of higher NO concentrations.

Control of Particulates from Street Sanding

According to the 1974 Denver Emissions Inventory street sanding and the resultant dust generation from automobile traffic is the major source of particulates in the Denver region. Also, street sanding and use of salts is a significant non-point source of water pollution in the region. Therefore, a program to mitigate the impact of this source of particulate air pollution will also have water quality benefits and vice versa.

Most controls for dust generated from paved streets are concerned with reducing the amount of material on the street surface. In a recent report which considered results from several studies carried out in cities other than Denver, three different methods of street cleaning were evaluated. (See reference 129). These were mechanical broom sweepers, vacuum sweepers, and flushers. None of these conventional street cleaning methods were found to be effective in all areas studied. Rather, the results are mixed. In some cases significant reductions in particulate concentrations were found, in others there was no measurable change. The relationship between cleaning and emissions is complex in that emission rates are not directly related to the loadings removed from the street nor closely related to the street surface loadings.

Street flushing, one of the methods examined, reduced particulate concentrations in certain studies. Apparently, flushing has an effect similar to rainfall, with a substantial reduction in particulate concentrations in the air on the day of flushing, but little effect on following days. A reduction of 16 $\mu g/m^3$ on the days of flushing is an estimate of the impact of this street cleaning method in high traffic density areas. Flushing, however, does not remove material from streets but moves it from traffic lanes to the curb. With subsequent rains or snowmelt, the suspended solids loadings in storm water runoff would not be reduced. In fact, short-term concentrations might be increased since the material is already concentrated in the gutters. Theoretically, a combination of flushing followed by a pickup of material in the gutter, with either broom sweepers or vacuums would provide optimum cleaning for both the air and water pollution control. However, in two studies where a combination of flushing and sweeping was performed, no significant reductions in particulate concentrations were observed.

In one study, broom sweeping was found to reduce average particulate concentrations but appeared to be ineffective in two others. This method of reducing street generated dust has limitations in that it moves material from the gutter back into the street and is not efficient in removing fine particles. As an optimum a 6 to 20 $\mu g/m^3$ reduction in average particulate concentrations in air might be achieved with a broom sweeper.

In the studies which evaluated vacuum cleaners they found no reductions in particulate concentrations. Dust may have actually been suspended in the air by escaping from the top of the vacuum sweeper. In one study, the insiginficant contribution of street sanding to the ambient particulate concentration may have negated any positive effect.

Because of these limited and mixed results, definite conclusions cannot be drawn as to the effectiveness of street cleaning as a control strategy for particulates. Demonstration studies in the Denver area would provide the best mechanism to determine the potential effectiveness of this street cleaning strategy in improving both air and water quality.

Although the relationship of street sanding to particulate concentrations is complex, it appears ambient concentrations are directly related to traffic volumes. Therefore, reductions in traffic volumes may present the most effective method of reducing the particulate air quality problem. Beyond controls which reduce automotive tail pipe emissions, reductions in vehicle use and miles travelled also appear to be the most effective measure for controlling carbon monoxide and ozone pollution. Therefore, Denver's air quality problem for all pollutants which are in violation of the National Ambient Air Quality Standards is and will continue to be highly related to the degree of dependence upon the automobile for transportation.

Implementation of Air Quality Mitigation Measures

As discussed earlier the reason for evaluating the probable air quality impacts and potential mitigation measures in this Environmental Impact Statement is to establish the most consistent approach practicable to meeting both air and water quality goals within the Denver region. The common element between these two environmental concerns is the effect of population growth and development within the region on air and water quality, given the feasible and implementable technologies for controlling these forms of pollution separately.

It appears that even with the emission reductions expected from the Federal emissions control program and with implementation of the inspection and maintenance program that air quality standards will continue to be violated through 1985 for ozone and CO and possibly until 2000. The particulate problem will persist with little relief in sight. By 2000, the ozone and CO problem will be reduced to within a range which will be very close to the standard, but violations may still be recorded. However, the effect of the vehicle emissions control program is expected to reach its peak reduction potential by around 1995. Therefore, any subsequent growth in traffic will cause the deterioration of Denver's air quality.

In considering options for promoting the mitigation of air quality impacts through EPA's wastewater construction grants program, it is apparent that excess capacity for growth is the principal issue. However, population growth is not in itself the problem, but rather, the air quality problem is more related to transportation. Can a decision by EPA on funding or not funding excess capacity for wastewater treatment facilities and interceptor sewer lines impact in any way the methods individuals use for transportation? Or will such decisions even effect regional population growth? What is needed is substantial individual and group commitment to solving the air pollution problem by reducing automotive use with greater expansion of transit systems and use of other less polluting modes of travel. What can EPA do in the actions being considered in the Environmental Impact Statement to gain this important commitment to improved air quality? This is a very difficult question, for which there is no apparent answer when considering the very limited authority of the Federal Government in local land use and transportation planning decision making.

Public Concern

This discussion of public attitudes in Denver as supported by previous surveys concerns public feelings towards emission control measures. The information presented here was taken from the same report referenced in Section II on public concern.

For controls requiring monetary commitments it was found in two surveys that about 90% of the respondents expressed some degree of favorableness toward paying $10 per year to reduce air pollution. When raised to $50 and $100 about 50% responded favorably. In another survey 54% expressed favorableness toward a $25-$50 tax increase for new transportation methods in the Denver area, but only 25% were willing to pay $5 for each trip to downtown Denver.

In one survey 90% of the respondents expressed a favorable attitude towards annual pollution testing of auto exhausts. Supporting this finding, two other surveys found that 80% and 85% were favorable to a period of mandatory inspection of emission control equipment. Also, three out of four respondents in the first survey mentioned in this paragraph were generally in favor of reducing downtown Denver traffic, although this figure fell to 64% if such a reduction meant limiting their own driving. Almost 80% said they were favorable to the idea of taking a bus downtown, and, in general, the respondents were not in favor of building more freeways or increasing traffic speeds as a means of lessening traffic congestion. Regarding the acceptability of various proposals for reducing congestion, the prohibition of traffic and parking in central business districts and the conversion of some lanes to "bus only" or "car pool only" lanes on major traffic arteries were most acceptable but given a mean rating of only "somewhat acceptable." Proposals for gas rationing and a $500 automobile registration fee were given a mean rating of "very unacceptable."

Results from surveys in other parts of the United States generally support these findings for Denver, of the public's expressed willingness to make certain kinds and degrees of sacrifice to promote air pollution control.

MITIGATION OF WATER QUALITY IMPACTS

The various strategies for control of point and non-point sources of water pollutants which were evaluated in the EIS will not result in water quality which will meet 1983 goals of "fishable, swimmable" waters. Thus, it is necessary to consider additional measures which may be taken.

Although future water quality will be influenced primarily by non-point sources, phosphates are an exception, point source control is necessary to achieve water quality goals during low flow periods and downstream from the Metro discharge to the South Platte. It is also possible that the water quality goals themselves are unrealistic or inappropriate for the Denver Region. Within these contexts, the following mitigation measures are evaluated.

Revise Water Quality Goals

The present water quality goals for most of the streams in the region were established to permit water contact recreation, warm water fishery, good aesthetics (appearance and odor), animal watering, irrigation and use of stream waters for water supply. If goals were reduced to include a smaller range of stream uses and benefits such as non-contact water recreation, warm water fishery, aesthetics and all other uses except as a domestic water supply, the goals would still not be met year around. Further relaxation of the goals would severely limit the recreational potential of streams, a resource of increasing importance in the future, and seriously impair domestic water supplies within and downstream of the Denver region. Thus, it may be possible to reduce the degree of control necessary for point and non-point sources of pollution and related costs by revising water quality goals, but the overall advantage appears small.

Improved Wastewater Treatment

Improving the water quality of discharges from wastewater treatment plants over and above that considered in the EIS or the Clean Water Plan would further improve stream water quality during low flow periods in general. However, a very effective non-point source control program would also be necessary to meet year round water quality goals. Phosphates are the only pollutant that will be dominated by point sources in 1983. All other pollutants are dominated by non-point sources contributing to water pollution upstream of the Metro discharge. Metro discharges of BOD, phosphates, and ammonia will be the dominate source of these pollutants in the South Platte downstream of the Metro discharge point. The quality of water when discharged to streams from municipal and industrial wastewater treatment plants, which would result in substantial achievement of water quality goals in association with non-point source control would have to be BOD, 5 mg/l; suspended solids, 5 mg/l; ammonia, 1 mg/l; phosphates, 0.3 mg/l, and total nitrogen, 2 mg/l. When discharges were not to streams, as for urban and agricultural irrigation, discharge quality should be BOD, 20 mg/l; suspended solids, 20 mg/l; ammonia, 3 mg/l; phosphates, 8 mg/l; total nitrogen, 5 mg/l; and TDS, 500 mg/l.

Non-Point Source Control

It has been estimated that in conjunction with high levels of point source treatment, a 75 percent reduction in non-point sources will be necessary in the South Platte basin, and 60% in the northern areas, to meet water quality goals. There are two basic approaches to non-point source control; structural and non-structural. Structural control involves the collection, storage, and treatment of urban runoff waters. Non-structural control involves such programs as more frequent and effective street sweeping, controls on domestic animals, greater litter controls, maintenance and cleaning of street catch basins, etc. The Clean Water Plan recommends a non-structural approach which, if implemented effectively and uniformly, is estimated to reduce non-point sources of pollutants by 30 percent. A structural approach was not recommended because of high cost and doubtful effectiveness. As a consequence, an expanded water quality monitoring program was proposed to more specifically identify non-point sources which in turn would permit the formulation of tailored and effective control measures.

Development and Growth Controls

Future water quality problems in the majority of the Denver region will be dominated by non-point sources of pollution even if the non-structural control program recommended in the draft Clean Water Plan were implemented and effictive. Future structural controls are likely to be limited to commercial and industrial areas of the region as there is significant evidence that the majority of a number of non-point sources of pollution originate from these areas. An additional category of mitigating measures not considered in the draft Clean Water Plan is limitation of the amount, type, or location of future growth.

The upstream portions of the South Platte and its tributaries beyond the urban fringe have significantly better water quality, and have the greatest potential for achieving water quality goals. Protection of these upstream areas can be achieved by stringent development controls which would:

1. Prohibit floodplain development and/or require a 200 foot stream setback.

2. Minimize impervious areas and vehicle use.
3. Provide for temporary on-site storage of runoff for eventual percolation into the soil.
4. Provide for the collection and temporary storage of initial or low volume runoff from commercial and industrial sites for eventual discharge and treatment by wastewater treatment plants during off peak hours.
5. Ban the use of septic tank leach fields.
6. Institute other non-structural controls as described in the draft Clean Water Plan.

Agricultural Reuse and Return Flows

The use of treated wastewater for agricultural irrigation is generally restricted in this country. This is because of possible health effects on both farm workers and the consuming public, and because of possible damage to agricultural soils. At the same time, the effects of agricultural return flows, classed as point sources, on stream water quality have not been investigated principally because no data on return flow water quality is available. As point and non-point controls are instituted, and agricultural reuse becomes more common, the importance of agricultural irrigation return flows will probably increase. Because of potential health, soil, and stream water quality impacts, the following measure should mitigate or control these impacts.

1. Establish irrigation water quality criteria necessary to protect the public health and the agricultural soils of the region.
2. Determine the current water quality of agricultural return flows and establish discharge requirements if necessary.

Regional Monitoring System

Although water quality monitoring is not a mitigative measure, per se, the 208 plan recognizes the importance of having an adequate data base from which to require the implementation of specific point and non-point control. Consequently, DRCOG has proposed a regionwide sampling network which consists of 30 sampling sites. Of these stations, 18 would be located so as to better define non-point source problems in the 208 study area. Presumably, once the relationship between man's activities and the resultant non-point source pollution is better quantitied, structural control of nonpoint source pollution will be instituted where effective and economically feasible.

MITIGATION OF AGRICULTURAL IMPACTS

Mitigating measures presented to mitigate growth and other impacts particularly for soil erosion, are pertinent to the mitigation of agricultural impacts. The following measures are presented in addition to those mitigating measures.

Water Conservation

Conservation of available water supplies can be effective in reducing competition for available supplies. Conservation efforts in the domestic and industrial use of water can reduce demand 20-30 percent from current levels. This would greatly relieve pressures to convert agricultural water rights to municipal uses. Conservation efforts in three broad areas would be effective:

1. Continuing public education programs on the need and ways of conserving water.
2. Metering of all water users so that excessive use can be determined and water conservation measures enforced.
3. Establish water use goals with a regressive rate structure for excessive use.
4. Ban the sale and installation of water using appliances that use excessive amount of water, e.g., ban the sale of flush toilets with tank capacity greater than three gallons.

Change Water Laws

It would seem effective to amend Colorado Water Rights laws to require that municipalities meet certain requirements and demonstrate they have exhausted all available alternative remedies to their water supply problems. These remedies to include water reuse and/or exchange agreements, water conservation, land use planning, and development controls. This is more stringent than HB 1555 enacted by Colorado in 1975.

Agricultural Land Transfer Tax

Various proposals and state laws in the United States have addressed the problem of agricultural land preservation. One proposal which appears to offer an effective mechanism is an agricultural land transfer tax. This basically involves a tax that would be levied when title or zoning is change for some use other than agriculture. This tax would be payable by the buyer and/or individual requesting a change in zoning classification.

MITIGATION OF ENERGY IMPACTS

Natural Gas Shortfalls and Their Effects on Urban and Rural Users

Because the Denver region has nearly 60 percent of Colorado's population, its market demand and political influence could affect the equitable distribution of the state's natural gas when supply shortfalls begin. State and federal energy allocation planning will be needed to assure that uses outside the region receive their fair share of available supplies. Also, within the region, planning will be needed to deal with supply and demand problems of electrical energy to minimize brown-outs or load reductions and shedding.

Secondary Impacts of Natural Gas Shortages on Electrical Power Generation

A major consideration of any statewide energy planning is that coal will be the main substitute for natural gas in the generation of electric power because of the general unacceptability of nuclear power at this time. Coal mining and processing activities and coal-fueled generating plants use vast amounts of water. Energy planning must consider the resolution of water use allocation problems that will occur in the near future due to coal production and use.

Regional Energy Conservation

Energy conservation is a recognized necessity throughout the country. The measures listed on Table V-A could be especially useful in the Denver region if implemented by appropriate authorities and accepted by the general public.

Energy Use in Wastewater Treatment Plants

The mitigations listed in Table V-B should be considered along with others during facilities design phases to assure that new and existing facilities will be as energy efficient as current feasible technology will allow. Back-up power generating equipment should be installed in existing and new facilities to anticipate power overages.

Table V-B. ENERGY CONSERVATION MEASURES FOR WASTEWATER TREATMENT FACILITIES

Mitigation	Remarks
Use of solar energy and in-house generated methane.	WWT plant process selection, design, plus solar power and methane could reduce natural gas demand by 90 percent for new facilities, 50 percent for existing.
Pretreatment of large industrial source wastes.	Reduces the energy demand of wastewater treatment plants.

Table V-A. ENERGY CONSERVATION MITIGATION MEASURES

Mitigation	Remarks
Energy conservation and solar use	
a. Residential/commercial conservation	Residential, commercial and industrial retrofit plus conservation measures incorporated into new development reduce region's energy demand, mostly natural gas, 10 percent in 1980, 30 percent in 1990.
b. Industrial conservation	
Farm management controls	
a. Runoff and erosion controls	Reduced fertilizer use reduces demand for fossil fuels used in its manufacture. Water reuse reduces energy demand, primarily electric power, of water distribution systems.
b. Water reuse	
c. Control fertilizer use in critical areas	
d. Require biodegradeable fertilizers, herbicides, etc.	
e. Restrict livestock/land ratios	
f. Treat irrigation return flows	
g. Increase penned animal controls for <1,000 head	
Collect and recycle auto oil	Reduces consumption of petroleum fuels/products
Auto inspection and maintenance	Reduces fuel consumption by vehicles by about 5 percent, demand for petroleum products 4 percent.
Development controls:	
a. Require high density development	Reduces demand for energy 10-20 percent for new development.
Water conservation	
a. Volume control devices	Reduces energy demand of wastewater treatment plants through reduced flow. Maximum reduction would be on the order of 50 percent attainable in 10 years. Also reduces energy demand of potable and irrigation water distribution systems.
b. Low volume flush toilets	
c. Low volume showers	
d. Low water demand landscaping and household devices	
e. Public education and reduce infiltrations	
f. Meter with regressive rate structure	
g. Reuse	

MITIGATION MEASURES FOR ADVERSE GROWTH-INDUCED IMPACTS

Most of the mitigation measures described in this section are beyond EPA's authority to implement. Thus, EPA will have to rely on other federal agencies and on state and local agencies if the measures are to be carried out. To this end, EPA may be able to function as a motivator and technical advisor to help other agencies, particularly those on the local level, to implement many of these tasks.

Because of the Denver region's complex framework of local government, these mitigations will not be uniformly applied, if at all. Thus, their real-world effectiveness at the present time is unpredictable. Until there is a state-mandated requirement for consistency between regional comprehensive plans and the granting of local land-use entitlements, no reasonable estimation of these mitigations' effectiveness can be made. For this reason, most of the impacts examined here are considered to be unavoidable. The ramifications of these andother unavoidable adverse regional impacts will be examined in subsequent sections.

Climate

Wind-Transported Dust and Soil Particulates from Construction Sites

Construction schedule planning by developers and local governmental regulations to require construction site soil stabilization during the windy season are the most appropriate means to mitigate this variably significant impact. If local dust and soil particulate problems are not being adequately controlled at this time by existing regulations, it may be in order for local governments to consider adopting new, more stringent ones in view of the current drought and its contribution to wind erosion. This could be done in conjunction with the site stabilization ordinance discussed under Soils in this section. Assistance to local governments in preparing new regulations could be made available by DRCOG, the U. S. Soil Conservation Service (SCS) and the Colorado State Soil Conservation Board (CSSCB). If this approach is not successful on a regional level, it may be appropriate for the State to enact such legislation as would require local governments to adopt and enforce effective construction site soil stabilization regulations. This approach is an extreme one which would be warranted only under the most severe combination of heavy, regionwide construction activity, continued drought resulting in "dustbowl" conditions, and inaction by local government to control severe wind erosion problems.

Increased Potential for Wind Damage in River Valley Wind Corridors--

Local planning and building inspection agencies should define historic wind damage factors in the river valley wind corridors and comparatively evaluate existing land use plans and building codes to determine whether they need revision to incorporate wind damage prevention measures. Such wind damage prevention measures might include prohibitions of certain building design features, signing design and construction standards, requirements for vegetative windrows at new project sites, and structure orientation standards. EPA Region VIII, the U.S. Department of Housing and Urban Development or DRCOG could be instrumental in preparing model wind damage prevention standards for the region.

Fog-Related Traffic Problems--

Fog conditions generally have a great areal extent and are largely unavoidable. Generally, any successful effort to reduce ealry morning commute traffic volumes will also reduce the potential for fog-related traffic problems.

Geology

Modification of Landforms and Hillside Construction

Local jurisdictions on the western edge of the region which are likely to experience hillside construction should evaluate existing local comprehensive plans and development standards to determine whether they adequately consider the special engineering, construction, aesthetic and environmental problems of such construction. If existing standards are inadequate, local government should revise them to focus attention on these special problems. EPA Region VIII, the U.S. Geological Survey (USGS), SCS or DRCOG could prepare a model ordinance for use by local governments to aid in this task.

Effects of Population Growth and Development on Significant and Unique Geologic Structures and Formations--

As part of local comprehensive planning efforts, significant and unique geologic structures and formations within each jurisdiction should be noted and adequate plans for their preservation and protection should be formulated if this has not already been done.

Local Mining and Geologic Hazards to Development--

Significant mining and geologic hazards within each jurisdiction should be identified, if they have not been already, as a part of local comprehensive planning activities. Existing development regulations relative to each type of hazard should be evaluated for effectiveness and revised as needed. Local jurisdictions should consider establishing programs to reclaim hazardous surface mining areas, seal mine shafts and restrict development in areas having subsidence potential because of past subsurface mining activities. DRCOG, with the help of USGS, should be called upon to help local governments identify hazardous areas and to develop model ordinances and programs focused on local conditions.

Soils

Increased Agriculture-Related Wind Erosion Due to Current Drought Conditions--

Mitigations relative to construction site wind erosion were discussed under Climate. The SCS, through the local conservation districts and CSSCB, should step up technical and educational assistance programs to help local farmers minimize topsoil losses during the current drought.

Water Erosion--

All jurisdictions in the region should examine their development standards to determine their adequacy to control erosion and runoff on construction sites. DRCOG, assisted by SCS and CSSCB, should be called upon to prepare a model erosion and runoff control ordinance for construction sites as a part of, or as an adjunct to, the current 208 planning program. This mitigation could be effective to some degree in reducing the sediment load in the region's drainage net.

Biology

Stream Channelization--

Structural treatments to watercourses are frequently a part of flood control measures. Stream channelization and related activities such as diversions and culverting adversely affect the aquatic environment. Municipalities and flood control districts should incorporate the following recommendations into any existing flood control design standards. Appropriate regional and state agencies should be called on to prepare a model set of flood control designs based on these recommendations to aid local agencies, if necessary.

Soft Channel Treatment--Flood protection can be achieved through alternative means such as broadening the channel and usage of earthen levees and flood walls to some degree. In this manner, protection is incorporated without drastic alteration of the stream bottom itself. This is a compromise measure, for even if vegetation is allowed to grow back, the channel will have a disturbed appearance.

Off-Channel Treatments--Stream channelization is minimized. Instead, combinations of flood-proofing and evacuation of the floodplain are adopted. This method should be more effective than soft channel treatments in protecting the aquatic environment. However, off-channel treatment generally requires more space.

Nonstructural treatments--Stream channelization and similar structural methods of flood protection in newly populated areas would not be used. Protection would instead utilize floodplain zoning, floodplain insurance, acquisition of land, including conservation easements, and eventual removal of human habitation from the floodplains. These measures go beyond the physical protection of stream channels, embodying conservation concepts that require policy changes and, in some cases, legislative action.

Upstream Conversion of Land to Urban Uses--

Mitigations for this effect would be covered in most of the channel treatments suggested under the preceding subsection. In particular, non-structural treatments would be most effective and are best suited for implementation prior to actual upstream land development. Measures to protect the local stream environments should be incorporated into the local land use plans. Technical assistance could be provided by appropriate regional agencies.

Industrial Activities near the Aquatic Environment--

Discharges from industrial and manufacturing facilities to local watercourses should require federal and state controls. The National Pollutant Discharge Elimination System (NPDES) permit system as administered by the state is aimed at protection of the local aquatic environment as well as maintenance of water quality. The impacts of future gravel mining along floodplain corridors could be minimized by rigorous local and state governmental standards and regulations. All mining activities should be required by State law, before local governmental approval, to prepare plans for protection of streams during construction and excavation, along with workable plans for reclaiming the stream channel after mining activities have ceased and for restoration to a viable riparian environment.

Disruption of Riparian Corridors--

Mitigations for this impact could be required through local comprehensive planning efforts and development standards. DRCOG could provide technical assistance through a set of model development standards should minimally consider the following recommendations:

(1) Design of facilities which minimize stream crossings or use of areas adjacent to streams.

(2) Inclusion of reclamation activities into the facility design. Restoration of disturbed areas by revegetation, re-creation of natural stream bottoms and other methods would mitigate some of the effects of stream crossings. However, with frequent human presence, these areas will always retain a disturbed composition.

Disturbance of Forest and Brushland Areas--

To protect the foothill and upland areas in the face of future development, any new development standards should also consider:

(1) Regulation of activities on all public lands specifically to control excessive ground-cover removal, resource harvesting and other human uses.

(2) Legislation applicable to both public agencies and private landowners on activities which may adversely affect the environment.

(3) Strict agency supervision of those controls which the general public and private landowners are required by law to follow. These include fire control measures, engine noise control measures, litter ordinances and others.

(4) Comprehensive planning for future land use in undeveloped and developing areas based on environmental limitations and opportunities.

Development near Unique Habitat Areas--

Adverse impacts on unique natural areas can be mitigated by:

(1) Official recognition, and designation to a protected status, where possible, by the appropriate governmental agencies,

(2) Comprehensive planning by local jurisdictions with technical assistance by DRCOG near these areas which minimize physical disturbance or introduction of large numbers of people to the area.

Increased Fire Hazard--

Several structural and nonstructural methods may be used to decrease the wildfire potential. These are generally preventive measures particularly applicable to foothill and mountain areas which should be instituted during local comprehensive and project development planning with the assistance of local, regional and state fire fighting authorities. Model wildfire hazard reduction standards could be developed by DRCOG or another appropriate agency. Such standards should consider:

(1) Thinning of dense tree stands near areas of human activity. This should be mandatory for homes built on slopes greater than 30 percent or on unstable slopes.

(2) Removal of trees close to homes and of branches overlapping rooftops, especially those near chimneys.

(3) Removal of extraneous flammable material such as debris on the ground and along roadsides. Pruning of dead limbs and removal of branches to a height of 8 to 10 feet near inhabitied areas would also help.

(4) Prohibition or strict limitation of outside burning.

(5) Provision for adequate access by fire-fighting equipment. Planning for emergencies, including familiarization with escape routes.

Aesthetics

The potential indirect impacts mentioned in Section IV can be lessened or corrected in many ways. However, a long list of suggested mitigation measures for impacts that may happen in the future cannot replace comprehensive planning that initially should be done by the local and regional planning agencies to preclude the occurrence of many of these impacts. The following is a list of the planning measures which if considered and implemented at the present time would reduce adverse aesthetic impacts.

(1) Development controls along stream corridors to protect the aquatic environment.

(2) Development controls in wilderness areas or natural units within urban areas to minimize disturbance to sensitive wildlife and unique ecological areas.

(3) Policy controls to limit developments which preclude public access to surface waters, scenic areas and recreational resources.

(4) In-depth planning of transportation routes and traffic circulation patterns which people can relate to and not feel overwhelmed or frustrated by.

(5) Comprehensive planning which balances the human needs for open space relationships, aesthetic appreciation of natural resources and "breathing space" in a modern environment agianst pressures for urban development and urbanization.

(6) Environmental protection measures for parameters not sturcturally definable such as clean air, ease of movement, visual landscape harmony and others.

Outdoor Recreation Sites

Potential Overuse and Resultant Damage to Existing Recreation Facilities Due to Population Growth--

Municipalities and their park departments throughout the region have tended to keep pace with the population's demand for urban recreation facilities in traditional terms of developing and maintaining widely scattered community parks and they will continue to do so in the near future. To prevent damages to these facilities from overuse, measures should be taken to provide neighborhood facilities for the primary, day-to-day needs of the public. Local governments should require developers to provide neighborhood recreation facilities through integral designs of usable open space in site plans, construction of neighborhood parks within developments, or payment of in-lieu-of fees to the local park agencies. DRCOG could aid those jurisdictions needing technical assistance in the preparation of appropriate ordinances and development standards.

Park Vandalism--

Model development standards which could minimize vandalism to park facilities should be prepared by DRCOG to aid local agencies in upgrading existing recreation sites, and in designing and constructing new ones.

Land Waste Disposal Sites

The most expedient and effective way to resolve the continuing land use conflict over sludge disposal at the Lowry Bombing Range is to develop and utilize a remote site such as that proposed for West Adams County as soon as possible.

Traffic

The Federal Urban Mass Transit Administration's (UMTA) denial of funds for a transit system in the Denver region has disrupted efforts to lessen the region's dependence on the automobile with an attractive alternative mode of transportation. The Regional Transportation District (RTD) with the aid of the State of Colorado and its Congressional delegation should continue seeking funds from UMTA for a modern regional transit system. This should be done to influence the extent and pattern of urbanization, conserve energy supplies and land resources, and take advantage of the economic efficiencies inherent in mass transit. At the same time, RTD should step-up efforts to use its bus fleet to the fullest extent by such means as acquiring exclusive bus lanes for use by short-headway, express buses; refitting express buses with comfortable, long-distance seats and maintaining the cleanliness of the entire fleet to the highest degree; constructing conveniently located suburban stations having ample, free parking along the express lines (the stations should be designed to served as fixed-rail stations at a later time); construct "park-and-ride" parking lots around the periphery of the central business district (CBD); and provide jitney bus service in the CBD. Other suggestions to increase ridership include a high quality, long-term advertising and education campaign, special event service schedules, simplified fare schedules such as monthly passes and education of RTD's public contact employees in the arts of public relations.

MITIGATION MEASURES FOR DIRECT IMPACTS

Climate

Seasonal Climate Events and Conditions Which Could Affect Facilities Construction--

Delays incurred in construction can be almost wholly avoided by phasing construction during periods of little or no adversive climate conditions such as in late spring and summer which is the accepted practice in the region. Surface disturbances should be limited to those areas where construction is actually under way. Disturbed ground surfaces should be sprinkled as needed to control fugitive dust. And, disturbed ground surfaces should be revegetated as soon as construction is completed.

Aerosol Production and Local Fog Formation--

A aerosol formation and local fog formation can be reduced substantially by utilizing low-rate, low pressure irrigation systems which employ large nozzles instead of high rate irrigation systems. Aerosol formation can be effectively reduced to zero by using drip irrigation instead of spray irrigation systems but this latter is prohibitively more costly.

Disruptions in Utility Services and Other Wind-Related Impacts on the Operation of Facilities--

Interuptions of electric power service could be reduced by placing all utilities underground. This can be more costly initially than constructing overhead lines, but it is less costly to maintain. Undergrounding requires only temporary alteration of the site. Wind damage to facilities can be reduced by surrounding treatment plants and ponds with vegetative windrows and/or berms. Berms would reduce possible adverse effects more than windrows but would be more costly to construct and would require more extensive alterations of existing vegetative cover and terrain. If windrows and berms are integrated into a facility's landscaping plan, they can be a positive aesthetic feature on the project site.

Geology

There were no direct impacts assessed for site-specific geologic conditions. Any significant site-specific conditions discovered during the design phases of the proposed facilities should be mitigated at thattime by qualified professionals.

Soils

Wind Erosion Impacts--

Mitigation measures for direct impacts of wind erosion were discussed under Climate, Seasonal Events and Conditions Which Could Affect Facilities Construction.

Water Erosion Impacts--

Erosion and runoff control plans should be prepared as a part of all facilities construction plans.

Biology

Disturbance of Loss of Vegetation and Wildlife Habitats--

Construction of the treatment plants and pipelines under all alternatives will involve removal of natural and introduced vegetation from construction sites. Wildlife utilizing these areas would also be disturbed form their normal patterns. Mitigation measures would include:

Limitation of construction activities, stockpiling of materials and personnel to the construction site only--This action would minize adverse effects on adjacent areas.

Design and placement of structures in areas of marginal habitat or that are already commited to human uses--This type of planning minimizes disturbance of natural areas by using existing roadways and urbanized areas.

Construction practices which preserve on-site vegetation and habitats to the maximum extent possible--The integration of existing natural vegetation into the project areas would preserve some wildlife habitat as well as facilitate recovery after construction. Retention of trees and ground cover, where possible, would also help stabilize the soil structure, Channel work, where necessary, should not be based on "high" velocity flows, but in general upon design velocities similar to present natural stream characteristics.

Reclamation program for construction sites--As soon as it is feasible after completion of construction, the exposed terrain could be regraded to a natural or semi-natural landform and revegetated. Restoration of ground cover, particularly native species, would facilitate return of some wildlife species. Due to the initial construction disturbance, sensitive species may migrate permenently to other areas. Thus, the level of success for this mitigation caction is the return and colonization of species tolerant to an altered human environment.

Disturbance of Aquatic Habitat During Construction--

Mitigation measures to minimize disturbance of the aquatic habitat include:

Limitation of construction activities to construction site only--Disturbance of the minimum amount of habitat during outfall construction could substantially reduce aquatic impacts.

Construction practices maximizing protection of the aquatic environment-- Revegetation or some type of structural treatment to exposed stream banks is important to prevent bank erosion and restore a riparian stream environment. In areas where the stream channel has been greatly disturbed, the recreation of stream habitats such as rock beds and pools along with removal of debris would hasten the return of an aquatic equilibrium to the stream environment.

Effects on Aquatic Environment During Facilities Operations--

The diversion of some effluent flows to local creeks due to the abandonment of local treatment plants would adversely affect the water regime in the local stream environments. This problem, coupled with legal water rights problems involving water supply to downstream water users, may require some insurance of maintenance of stream flows. Thus, measures which allow for a compensating upstream water release, if possible, would mitigate this impact to some degree.

Traffic

Because no significant adverse effects are anticipated, no mitigation measures are recommend.

Historic Features

Facility planner should plan all phases of materials delivery and construction so that historical sites and districts near the project site and along all thoroughfares to the site will be avoided whenever possible. The State and Federal procedures for preservation of historic and archeaologic preservation will be adhered to.

Outdoor Recreation Sites

The facility planner for each proposed project should investigate the site and its surroundings for any recreation sites that might be affected by construction or operation of the facility. When there is a possibility of impact, the facility planners and the responsible agency should be required to contact the appropriate recreation agency to work-out a mutually acceptable set of solutions to problems which might arise.

Aesthetics

Construction Effects

Mitigation measures to ameliorate the aesthetic impacts of construction are in most cases covered under physical impact mitigation in other sections. In brief, these include;

(1) Dust control measures during earth-moving such as water sprays.

(2) Emission control devices on heavy machinery where feasible.

(3) Careful scheduling to minimize disruption of human land use patterns.

(4) Conducting a public relations program prior to and during construction to keep public informed of project status and anticipated degree of impact to local community.

Operation Effects--

The aesthetic impacts of wastewater treatment facilities operations can be mitigated by the following measures:

(1) Design phase considerations to plan the wastewater facilities in a manner which can be compatible with the local area landforms, architectural context and natural context.

(2) Operation activities and scheduling which minimize noise, odors, night-time lighting and vehicle and personnel movements.

(3) Appropriate landscaping or architectural design around treatment plants which either mask the structures or draw attention away from them.

(4) A public relations program which informs the public about plant operations. In some cases, excess public land at the treatment plant site can be developed in public recreation and multiple-use areas.

VI. Unavoidable Adverse Impacts

SECTION VI

UNAVOIDABLE ADVERSE IMPACTS

REGIONAL UNAVOIDABLE ADVERSE IMPACTS

1. The region will continue to grow in both population and urbanized areas at the expense of existing and potential agricultural areas. The existing, complex framework of government agencies will hinder the solutions of region-wide problems.

2. Urban sprawl is expected to continue with the migration of the affluent and advantaged to the suburbs. Out-migrants from the urban core will be replaced in large measure by the poor, the old, minorities, and the disadvantaged. Economic growth in the suburbs will be more rapid than in the urban core. Physical and economic decay of the urban core is expected.

3. Damage to park and recreational facilities resulting from overuse or vandalism will continue and intensify as park acreage per capita ratio decrease.

4. Public health and soil damage impacts will occur as a consequence of agricultural irrigation with wastewater treatment plant effluent unless State of Colorado and local public health and agricultural officials establish effective effluent quality standards.

5. Particulate air pollution concentrations can be expected to increase in future years resulting in continued violation of the National Ambient Air Quality Standards. The major sources for particulates will continue to be related to construction activities, and materials on streets thrown up by vehicular traffic.

6. With the implementation of a vehicle emission inspection and maintenance program, carbon monoxide concentrations on a regional scale will be near to but still exceed standards in 1985. Peak ozone concentrations will continue to violate standards for the same year. By the year 2000, carbon monoxide on an average regional basis will meet standards, but high volume traffice corridors and interestions will continue to have "hot spot" carbon monoxide violations. Peak ozone concentrations will be near, but still occasionally exceed standards. The high per capita usage of the automobile by residents of the Denver region will continue

to be the major source of carbon monoxide, ozone and particulates pollution.

7. The implementation of any of the three major alternatives or the recommendations of the Clean Water Plan will likely result in an improvement in existing stream quality, but not in a degree sufficient to meet 1983 goals.

8. The region will experience natural gas supply shortfalls by 1978-1979.

9. Increased dependence on coal for electrical power generation will create new water allocation and quality problems.

10. Energy is not likely to be conserved to the degree necessary to avoid natural gas supply shortfalls or to reduce the region's future dependence on coal-generated electricity.

11. Construction site erosion and runoff will continue to be an important short-term impact on water quality throughout the region.

12. Stream channelization and related activities such as diversions and culverting in newly developing areas will adversely affect the aquatic environment at points throughout the region, particularly in upstream locations.

13. Industrial and mining activities along the region's streams will continue to adversely affect riparian and aquatic habitats.

14. Continuing development of all types will disrupt riparian corridors.

15. Future development in foothill and upland areas will disturb the habitats and ranges described in Section IV.

16. A number of unique habitat areas will be disturbed by future development, overuse of sites, trespassing and vandalism.

17. The Regional Transportation District will continue having difficulties competing with the automobile and achieving the utilization of its bus fleet until such time the automobile becomes an economically undesirable means of transportation.

18. Susceptibility to losses to topsoil and economic losses in agricultural sector under drought conditions is likely to increase.

19. Continued development in wind corridors will increase the potential for Chinook-related damages to some degree.

20. Increased traffic volumes on stream valley thoroughfares will increase the occurence and severity of fog-related traffic problems.

21. Aesthetically unattractive and potentially hazardous hillside development is likely to occur in some jurisdictions.

22. Some significant and unique geologic structures and formations in the region are likely to be damaged or defaced by overuse and vandalism.

23. Some mining-related hazards will threaten the safety and well-being of local residents in some jurisdictions.

UNAVOIDABLE ADVERSE IMPACTS OF WASTWATER FACILITY CONSTRUCTION AND OPERATION

1. Aerosols and local fogs will be produced at the facilities.

2. Erosion and run-off impacts would likely be unavoidable if the wastewater treatment plant construction-related mitigation measures recommended in Section V, Mitigation Measures for Direct Impacts, are not carried out.

3. Construction will eliminate human-sensitive wildlife species from the project sites.

4. Treatment plant odors should be considered an unavoidable impact because of the unexpected nature of the climate and operations upset conditions resulting in their production.

VII. Short-term Uses vs. Long-term Productivity

SECTION VII

LOCAL SHORT-TERM USES VERSUS MAINTENANCE AND ENHANCEMENT OF THE LONG-TERM PRODUCTIVITY OF THE ENVIRONMENT

1. The proposed projects under all three alternatives would improve the region's water quality. The local and no-action alternatives would result in marginally better water quality on a region-wide basis than would be the case for the regional alternative. However, 1983 standards will not be met by any of the alternatives alone nor by the recommendations of the Clean Water Plan. This is because nonpoint sources of pollution become even more controlling as regional growth continues. The review of the nonpoint source situation in this EIS reveals that nonstructural control measures alone are inadequate to reduce this category of pollutants if historic forms of urbanization continue, and that costly structural control measures will be required if standards are to be met. Thus, water quality improvements achieved with point source controls may well be short term in nature.

2. All three alternatives and the Clean Water Plan will provide additional sewer capacity to accomodate the growth, and attendant impacts, expected in the region. The local and no-action alternatives, however, may reduce the ability of some future regional government to use sewer facility construction as a tool to control the rate, distribution and density of development.

3. Tax monies payed by the residents of the region will be returning to the region to improve water quality and provide jobs, both of which will have beneficial effects on the regional economy. The local alternative would generate about 4,100 person-years of construction employment over the next five to six years, and the regional alternative, about 3,900 person-years of construction employment. All alternatives would mitigate construction trades unemployment, and maintain pressure from this economic sector for further urban development.

4. The local and no-action alternatives facilitate water reuse and augmentation of local stream flows. Flow augmentation will improve riparian and aquatic ecosystems, and aesthetic and recreational opportunities. However, a dependance on these augmented flows will result in a tendency to foreclose future options for use of water resources. These alternatives would also reduce water rights disputes as treated wastewater would be in closer

proximity to agencies wishing to maintain or exercise those rights, thus promoting water reuse and successive use in a region with water resource problems.

5. The no-action alternative would increase the financial burden of agencies and districts responsible for wastewater collection and treatment by about $70 million over that occurring under the other alternatives. This would ultimately impact residents of the region through increased user charges. This may result in a decreased willingness or capacity for residents to support other public service and/or facility costs particularly in the city and county of Denver.

6. Future urban growth in the Denver region will absorb 38,000 acres of prime agricultural land. Further economic and physical decay of the urban core is also likely. Thus, short term benefits will occur to suburban communities and associated developments to the long term detriment of agricultural productivity of the region and of the urban core.

VIII. Irreversible and Irretrievable Commitments of Resources

SECTION VIII

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

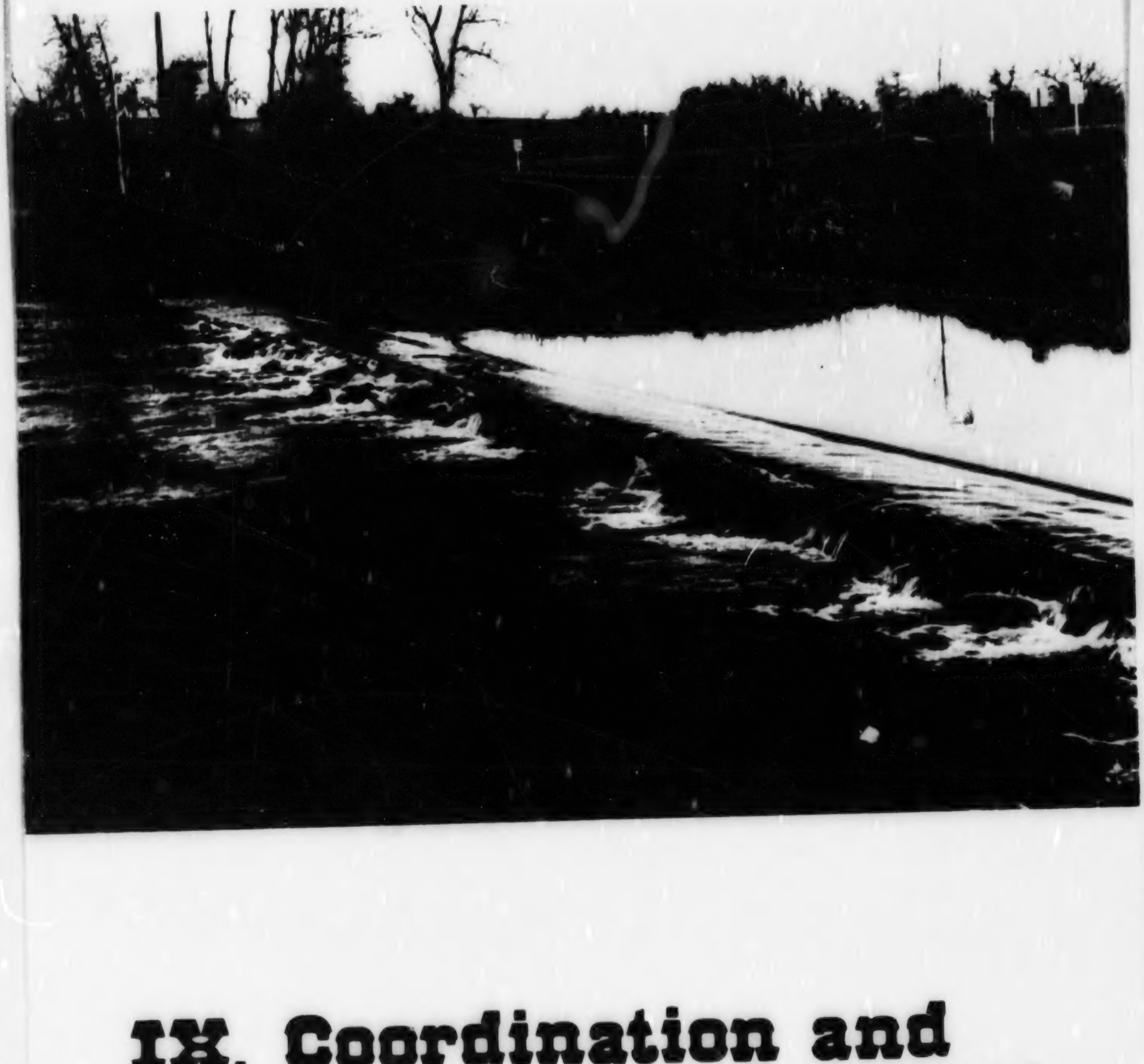
Implementation of any of the alternatives will require an irretrievable consumption of construction materials, fuels, labor and funds.

All alternatives would support planned future growth in the region, with its implied commitment of resources. Federal participation would be diminished under the no-action alternative. Under the other alternatives, federal participation in the following growth-related irreversible and irretrievable commitments of resources would occur:

(1) Conversion of prime agricultural lands and open space to urbanization;

(2) Consumption of limited petroleum-based liquid fuels in the construction of facilities and by the transportaion system; also, commitment to inadequate supplies of natural gas, upon which the residential, commercial and industrial sectors are very dependent;

(3) Increased commitment of available water to urban uses in an area of the nation constrained by limited water resources.



IX. Coordination and Public Involvement

SECTION IX

COORDINATION AND PUBLIC INVOLVEMENT

A Technical advisory Committee was established to assist and advise in the preparation of the draft Environmental Impact Statement. Membership was made up of representatives of local, regional, state and federal agencies, and citizen groups. The TAC's membership consisted of:

Mr. Gary Broetzman
208 Coordinator
State of Colorado

Mr. Walt Kelm
U.S. Department of Housing
and Urban Development

Mr. David Klotz
Denver Regional Council
of Governments

Ms. Purnee McCourt
Colorado Open Space Council

Mr. Robert Moore
U.S. Bureau of Land
Management

Mr. Warner Reeser
Colorado Air Pollution
Control Division

Mr. Leonard Slasky
Colorado Department of Highways

Mr. Larry Smith
Federal Highway Administration

Mr. Kenneth Webb
Colorado Water Qualtiy Control
Division

Ms. Toni Worcester
League of Women Voters

Mr. Ken Slyziak
Regional Transportation District

This draft EIS was also coordinated with the Federal Regional Council, made up of representatives from federal agencies in the region.

A major compaign will be conducted during the public review of this draft to inform and promote the involvement of the general public. Special presentations will be made to selected governmental and citizen groups, and general presentations made to as many groups as can be accomodated. Print and broadcast media contacts will be made and materials furnished to effect widest possible coverage of the draft EIS. A special newspaper supplement will be distributed by regional newspapers to inform the public and encourage attendance at a public hearing.

The 208 program has had its own public involvement program. Included in this element of the 208 program are:

(1) Community workshops, meetings, etc.

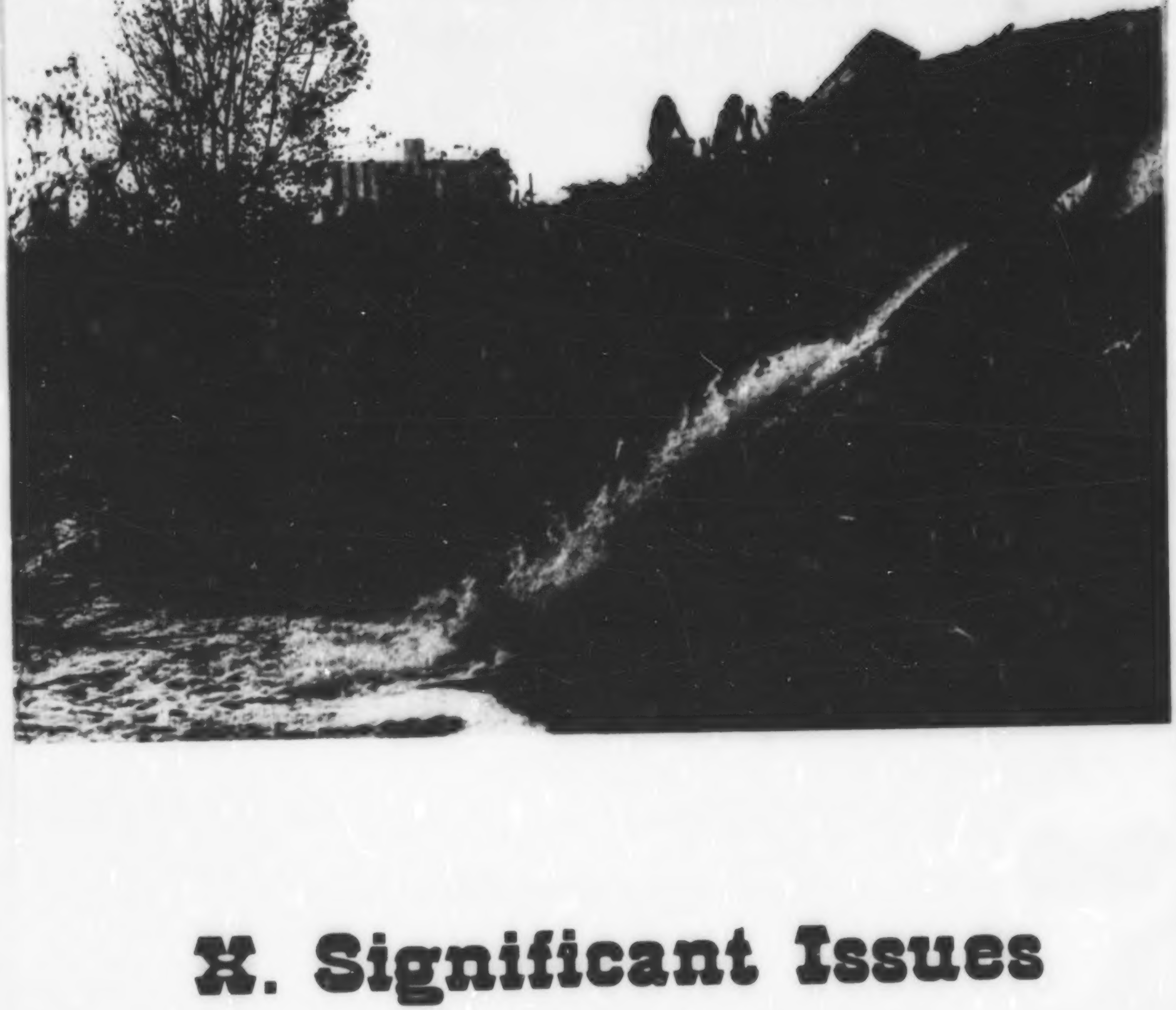
(2) Water Quality Advisory Task Force monthly meetings

(3) 208 presentations at local service clubs, schools, etc.

(4) Development and distribution of handouts, television public service spots, slide shows, etc., and

(5) Series of public meetings followed by a public hearing to consider the "Plan Report".

Despite the efforts of DRCOG to obtain public interest in the Clean Water Program, widespread knowledge of the project does not exist throughout the Denver area.



X. Significant Issues to be Resolved

SECTION X

SIGNIFICANT ISSUES TO BE RESOLVED

Water quality goals will not be met by any of the proposed alternatives, singly or in combination with the recommendations of the Denver Water Quality Management Plan (208 Plan). Even though DRCOG worked with over sixty agencies in developing the plan, there is no assurance that the 208 Plan recommendations will be carried out, given the complex institutional setting of the Denver region. Without such assurance, the long-term value of EPA investments in treatment level and capacity of municipal wastewater treatment plants in the region is open to question.

Actions of other federal agencies may minimize the effectiveness of EPA, state and local actions to improve water quality and mitigate adverse environmental impacts resulting from the continuation of historic forms and patterns of urban growth. Such patterns result in adverse environmental impacts regarding, air quality, loss of prime agricultural land and competition for available water and energy resources. The mechanism for effective coordinated federal action by all agencies has yet to be developed and remains at issue.

As discussed throughout this document, air quality is forecasted to improve over the next two decades, with the exception of particulates. However, standards for CO and ozone will continue to be exceeded over much of this period. No air quality projection has been made for Denver beyond the year 2,000, and the impact of pollutant emissions in Denver on downwind residents is also yet to be determined. This situation of continued air quality problems will continue to impact the health of the Denver region populace. While the major source of the problem has been identified as the automobile, present projections indicate increased vehicle usage in the Denver region. Federally required emission controls and the possibility of an emissions inspection and maintenance program are expected to be the principal strategies for reducing pollutant concentrations. For particulates, vehicle emission controls will not impact future concentrations and the present problem is expected to get worse.

Following are some of the remaining significant issues concerned with air quality downwind of the Denver Region.

(1) Air quality forecasts were limited to the Denver region. Air quality 50 to 150 miles downwind of the Denver region may not improve.

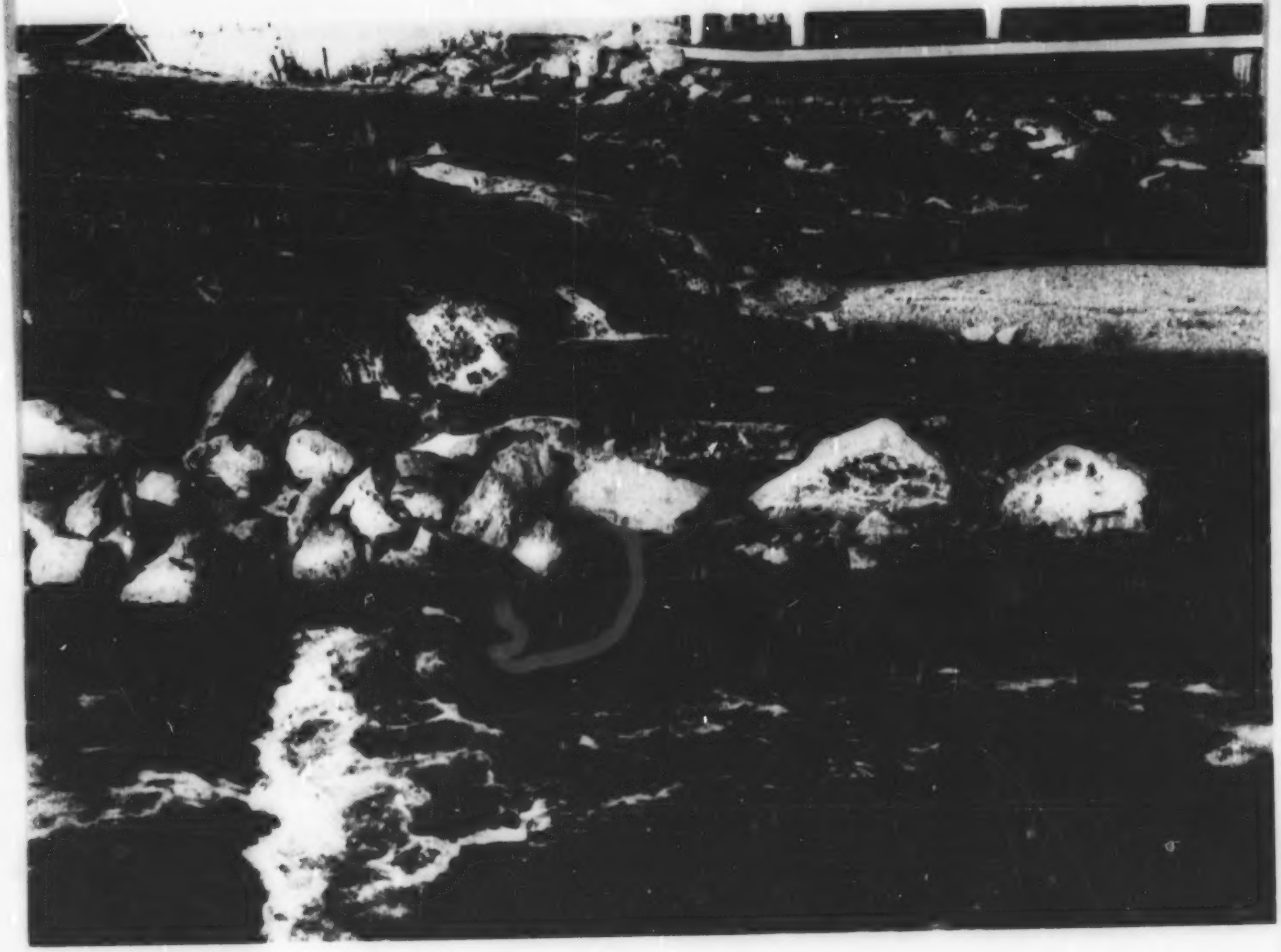
(2) The increase in particulates may cause small but significant climatological changes downwind from Denver.

(3) Increased use of coal as fuel for stationary sources and as a replacement for oil and natural gas may result in higher levels of pollutants, particularly sulfates and particulates.

These considerations raise issues yet to be resolved about future air quality downwind of the Denver region.

In the context of the proposed waste water facility funding being considered here, there appears to be no clear cut approach for EPA to address this air quality problem other than the no-action alternative. However, the no-action alternative is not expected to significantly change the future situation either in terms of air or water quality and would only limit Federal participation in the future. What is needed is a commitment by individuals and private and public institutions to reduce dependance upon the automobile. Potential gasoline shortages and higher prices may eventually induce this change in life style without this prior commitment to significant air quality improvement.

Implementation of many of the mitigation measures discussed earlier will be a difficult task at best, due to the multi-jurisdictional problems that exist within the Denver Metropolitan area. In funding wastewater treatment systems, many times EPA works directly with special Sanitation Districts that serve, but are not tied directly to, municipal governments. In these cases, this relationship restricts EPA's ability to negotiate special conditions which might mitigate certain specific adverse land use impacts. Additionally, there is no regional authority presently responsible for control of nonpoint pollution from urban runoff. Therefore, the present improvement of water quality, through control of both point and nonpoint pollution sources, is effectively limited by the lack of a nonpoint source management agency. These jurisdictional and management difficulties are not limited to water pollution control but also include areas of water supply, flood control, recreation, regional development, transportation, air quality, agriculture, and others involving the region's social welfare. Consolidation of responsibilities or other measures to develop regional responsibility and authority, such as discussed under the Section on Mitigation Measures, appear to be the most effective means to gain more effective implementation of worthy environmental mitigation measures.



XI. Glossary and Bibliography

SECTION XI

GLOSSARY

Activated sludge--A process which removes organic matter from sewage by saturating it with air and adding biologically active sludge.

ad valorem tax--A general property tax levied annually on real and personal property as listed with the county assessor.

Aerosol--A suspension of fine solid or liquid particles in a gas. In wastewater treatment processes involving spraying, aerosols can transport micro-organisms and dissolved liquids in the wind for considerable distances.

Aggregate--Any of several hard, inert materials, such as sand, gravel or slag, used for mixing with a cementing medium to form concrete, mortar or plaster.

Agricultural multiplier--A term which describes the number of times money generated by the agriculture sector of a regional economy changes hands before leaving that economy.

Anaerobic digester--A type of equipment used to digest sludge in the absence of oxygen to reduce the volatile organic material to methane gas by microbial activity.

Aquatic environment--The ecologic conditions extant in the region's streams and water bodies.

Aquifer--A water-bearing stratum of porous rock.

Benthic organisms--Organisms which live on the bottoms of water bodies.

Berm--A structure resembling a dike which is used as a means of physical separation.

BOD$_5$--An abbreviation representing the amount of oxygen required for the biological decomposition of dissolved organic solids to occur under aerobic dontions for five days at 20°C.

Braided stream--A stream with an interlacing network of channels.

Brown-out--A period of reduced illumination resulting from demands for electric power which exceed generating capacities.

Carbon monoxide (CO)--A very toxic, colorless and odorless gas.

Carrying capacity--A relationship reflecting the number of animals and/or humans that a given unit of land can support with a substantial degradation of that land unit's extant conditions.

cfs--An abbreviation for cubic feet per second. It is a unit of measurement commonly used to describe volume of streamflow.

Dewatering--A process where sewage is reduced in volume by removing a portion of its water content.

Diurnal--A term used to describe a 24-hour cycle.

Effluent--The liquid that comes out of a treatment plant after completion of the treatment process.

Emissions--Substances discharged into the air.

Environmental limitations--Those features of a defined area of land which could be degraded if new land uses were introduced.

Environmental opportunities--Those features of a defined unit of land which provide distinct advantages to certain introduced land uses.

Epidemiological--The sum of the factors controlling the presence or absence of a disease or pathogen.

Eutrophication--A process by which a body of water becomes overly rich in nutrients and deficient in oxygen.

Fugitive dust/particles--Dust and soil particulates carried by winds away from an earth disturbance.

Gaussian plume model--A mathematical model used to predict the distribution and dilution of air-borne substances from stationary sources.

General obligation bonds--Bonds secured by the full faith and credit and by the general taxing power of the issuer.

Holistic--A view that nature is correctly seen in terms of interacting wholes that are more than the mere sum of elementary particles.

Hydrograph--A graphic presentation of quantified streamflow characteristics.

In-liew of fees--As used in this document, recreation facility in-lieu of fees would be payed by residential developers, if they were not required by local jurisdictions to provide outdoor recreation facilities within their developments. The monies collected would be used by local jurisdictions to develop parks and playgrounds.

Interceptor--Interceptor sewers in a combined system control the flow of the sewage to the treatment plant. In a storm, they allow some of the sewage to flow directly into a receiving stream. This protects the treatment plant from being overloaded in case of a sudden surge of water into the sewers. Interceptors are also used in separate sanitation systems to collect the flows from main and trunk sewers and carry them to the points of treatment.

Intermittent stream--A stream which flows only during a part of a year. This contrasts with perennial streams which flow all year and ephemeral streams which carry only stormflows.

Inversion (temperature)--A reversal of the normal atmospheric temperature gradient.

Isopleth--A line on a map connecting points at which a given variable has a specified constant value.

Mill levy--An ad valorem tax.

Mini-NEPA laws--State and local laws, such as the California Environmental Quality Act, which are modeled after the National Environmental Policy Act to assure environmental review of state and local actions which might adversely affect the quality of the environment.

NO, NO_2 and NO_x--Oxides of nitrogen which are significant contributors to the formation of photochemical smog.

Non-point source--An activity distributed over a wide area that is a source of pollution.

Nonstructural control measures--Regulations and maintenance activities which reduce the production of pollutants without relying on equipment or facilities specifically designed to reduce the target pollutants.

Ozone (O_3)--A major agent in photochemical smog.

Particulate matter--Any material, except uncombined water, that exist in a finely divided form as a liquid or solid.

Perturbation--As used in this document, a perturbation is a hypothetical disturbance or change to extant conditions for the purpose of comparative modeling.

Point source--A stationary, readily identifiable pollution source.

Potable water--Drinkable water.

Precursor--A substance from which another substance is made.

Prototype meteorological day--A day whose quantified weather characteristics are representative of an area. These characteristics are used in mathematical models of air pollution conditions.

Radiation fog--A ground fog produced when the dew temperature (point of condensation) is reached through direct radiation of ground heat.

Revenue bonds--Bonds secured by a pledge of revenue which is to be derived from the operation of a public facility.

Rilling--A form of water erosion where very narrow and shallow furrows are created on exposed ground surfaces.

Riparian corridors--Biotic communities along stream courses used by wildlife as movement corridors.

Riparian habitat--A streamside biotic community.

Sedimentation--The process of particulates settling out of their transporting medium, e.g., silt, sand and gravel settling to the bottom of a stream.

Sediment load--The amount of particulates carried in a transporting medium.

Seismic activity--Earth shaking and movements.

Septic tank leachate--The incompletely treated liquid component of sewage processed by a septic tank.

Service/user charges--A regular charge levied on sewer system users by a responsible agency for the provision of services.

Setbacks--A land use restriction commonly employed for a number of health, safety and environmental reasons to prevent or limit construction in a given area, ususally to provide a buffer zone.

Shedding--Load shedding is a prearranged action by electrical power supplier and their major consumers where voltage is cut back by the supplier to the consumer or power demand is reduced by the consumer to prevent system-wide power shortfalls.

Sheet erosion--Soil erosion where water draining from an exposed ground surface does so in wide, even "sheets" and thus does not form any rills, rivulets or gullies.

Shortfall--As used in this document, a shortfall is a failure to meet an energy need.

Shrink-swell--A characteristic of soils containing clay which describes the range of volumes per unit weight of soil under wet and dry conditions.

Sludge--Sludge is the solid matter that settles to the bottom, floats or becomes suspended in the sedimentation tanks and must be disposed of by filtration and incineration or by transport to appropriate disposal sites.

SMSA, Standard Metropolitan Statistical Areas--Geographical units of land established by the U.S. Census Bureau to aid in its population data collection and analysis activities in urban areas.

Stationary sources--Nonmobile air pollution sources, e.g., refineries and factories.

Steppe--An arid, mid-latitude, continental natural region characterized by vast, flat and treeless expanses.

Strata--Sheets of sedimentary rock or earth covering one another.

Stream channelization--A human activity intended to modify natural stream channels to increase their volumes of flow.

Structural control measures--Facilities or equipment, such as wastewater treatment plants, which are specifically designed and constructed to abate a given pollution problem.

Subsidence--An event or occurrence where the ground surface settles or sinks to a new level.

Suspended solids--The small particles of solid pollutants which are present in sewage and which resist separation from the water by conventional means.

Synergistically--Several discrete agents having the ability to cooperate such that the total effect is greater than the sum of the agent's effects taken independently.

Tap fees/Connection fees--Initial fees charged by a sewer agency to allow connection to a sewer system.

Transition Life Zone--A term categorizing environmental characteristics found between 5,500 feet and 8,000 feet elevation.

Trickling filter—A support media for bacterial growth, usually a bed of rocks or stones. The sewage is trickled over the bed so the bacteria can break down the organic wastes. The bacteria collect on the stones through repeated use of the filter.

Upper Sonoran Life Zone--A term categorizing environmental characteristics found between 3,500 feet and 5,500 feet elevation.

Volatilization—A process whereby a liquid is caused to atomize or evaporate quickly.

Wildfire--Uncontrolled fire in undeveloped areas such as forests, brushlands and grasslands.

Wind corridors--Stream valleys descending out of the mountains onto the plains where valley depressions channel downslope winds. These channeled winds attain higher velocities than winds found elsewhere in the area due to Venturi effects resulting from the constricting stream valley landform.

Window--Linearly planted, closely-spaced trees utilized as a wind barrier.

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